INSECTS OF HAWAII

To Harold St John,
with best wishes,
Elwood C. Zimmerman

PREFACE TO VOLUME 5

This fifth volume of *Insects of Hawaii* includes information concerning 196 species of sternorhynchus Homoptera, or jumping plant lice, white flies, aphids, mealybugs and scale insects. Unlike the other volumes of this series which include large numbers of endemic insects, only 32 species of Psyllidae and 15 species of Pseudococcidae are native—the other 149 species have all been accidentally imported to Hawaii by man.

All the Aleyrodidae, Aphididae, Margarodidae, Ortheziidae, Asterolecaniidae, Kermidae, Coccidae and Diaspididae established in the islands are foreign species, and most of them are pests of economic importance. Some of them are vectors of plant diseases, and others cause great damage by their mass-attack on many kinds of plants.

Expenditures for insecticides and labor for the control of these insects in Hawaii each year are surprisingly large. Over the years, the control of the pineapple mealybug alone has cost millions of dollars. Many beneficial insects have been purposely introduced to aid in the control of the more important pest species by natural means. Some of these importations have been followed by excellent biological control, but there remains much to be done on this phase of our work. The most important pest listed in these pages, the pineapple mealybug, has not yet yielded to biological control, but I believe that someday a combination of natural factors may be discovered which will result in a marked reduction in the mealybug populations, and that the vast sums now expended on chemical control will be saved or greatly reduced.

There are few insect-borne plant diseases established in Hawaii compared to the number which might become established here. About 50 kinds of aphids have invaded our islands, and many of these are capable of transmitting plant diseases with which we fortunately do not now have to contend. The establishment of other insect-borne plant diseases in Hawaii is an ever-present menace; it is possible that some diseases new to Hawaii may break through quarantine barriers at any time.

Reference should be made to the "Preface to the First Five Volumes," in Volume 1 of this work, for a detailed outline of these volumes, general acknowledgments and comment. The other volumes of this series are: 1, *Introduction;* 2, *Apterygota–Thysanoptera;* 3, *Heteroptera;* and 4, *Homoptera: Auchenorhyncha.* There remain to be completed about ten volumes to include the more than 4,000 insects belonging to the orders Ephemeroptera, Neuroptera, Trichoptera, Lepidoptera, Coleoptera, Strepsiptera, Hymenoptera, Diptera and Siphonaptera. Only about one-fifth of the known insect fauna of Hawaii is covered by the volumes now completed; and some of the most remarkable endemic products as well as some of our most economically important insects are yet to be discussed in such assemblages as the 1,600 kinds of beetles, 1,000 kinds of moths, 1,000 kinds of wasps and bees and 400 kinds of flies. Most of the fact-gathering and bibliographic work for these future volumes has been completed. Final preparation and publication rest largely upon time and facilities being made available for the work, upon the acquisition of adequate illustrations, and upon moral and financial support of this project, the completion of which seems essential to facilitate advancement in the ever-growing, increasingly complex problems of entomology in Hawaii.

This volume has a sound base in its many illustrations, and I am deeply indebted to the artists who made them. G. F. Ferris, Stanford University, and Frieda Aber-

nathy, University of California, made most of the drawings and, unless otherwise mentioned, the photographs were made by W. Twigg-Smith and J. T. Yamamoto, Experiment Station, H.S.P.A.

Professor Ferris' contributions to this work have been extraordinary. Not only did he read and annotate copiously my original manuscript on the Coccoidea, but he illustrated the entire section. Many weeks of his own time were spent in preparing new illustrations for this text, and he also supplied a large set of his original drawings of the Diaspididae, many of which were previously used in his monumental *Atlas of the Scale Insects of North America.* Permission to use illustrations published in his *Atlas* has been kindly given by the Stanford University Press, and a list of them appears on the copyright page of this volume, and further acknowledgment is given in the caption to figure 178 on page 354. Professor Ferris also described a number of new endemic Pseudococcidae encountered during the preparation of this text; other notes on his aid are on page 134.

Dr. Harold Morrison, U. S. Bureau of Entomology and Plant Quarantine, Washington, D.C., read the section on the Coccoidea, made many helpful suggestions and identified a large amount of material during the preparation of this text. Further acknowledgment of his aid is included on page 134. Professor E. O. Essig, University of California, read the chapter on the aphids and supervised Mrs. Abernathy's excellent drawings for that section. He identified a large amount of material and has aided in many ways. D. D. Jensen, University of California, read the manuscript on the Psyllidae and Aphididae. Louise Russell, U. S. Bureau of Entomology and Plant Quarantine, Washington, D.C., read the manuscript on the Aleyrodidae. C. E. Pemberton, Experiment Station, H.S.P.A., read the manuscript on the Aphididae and checked the text and illustrations in laboratory work. Howard McKenzie, California State Department of Agriculture, Sacramento, read the coccid manuscript with particular attention to the Diaspididae. Walter Carter, Pineapple Research Institute, Honolulu, read the section on the pineapple mealybug. D. T. Fullaway loaned specimens of aphids and coccids for study.

My colleague, R. H. Van Zwaluwenburg, Experiment Station, H.S.P.A., has been especially helpful throughout the preparation of these volumes. He read the original manuscript of some 2,400 pages, read and checked the galley proofs and page proofs, and spent many hours checking references and other details. His aid has done much to make these volumes better and more accurate.

I wish to express again my gratitude to the staff of the University of Hawaii Press under the able direction of Thomas Nickerson, which has been so helpful and cooperative during the several months I worked in their offices during the editing and publishing of these five volumes. Juliette Wentworth and Margaret Blegen have shared the burden of editing these pages and reading the proofs with me. They have been keen and faithful colleagues, and I am deeply indebted to each of them.

E.C.Z.

Honolulu,
September, 1948

INSECTS OF HAWAII

A Manual of the Insects of the Hawaiian Islands, including an Enumeration of the Species and Notes on their Origin, Distribution, Hosts, Parasites, etc.

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VOLUME 5

HOMOPTERA: STERNORHYNCHA

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Order HEMIPTERA

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Subfamily Triozinae

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- **hawaiiensis** Crawford
- **iolani** Kirkaldy
- **kauaiensis** Crawford
- **lanaiensis** Crawford
- **lehua** Crawford
- **molokaiensis** Crawford
- **pullata** Crawford
- **ohiacola** Crawford
- **uniqua** (Caldwell)

Genus **Kuwayama** Crawford
- **gracilis** Crawford
- **minuta** Crawford
- **minutura** (Caldwell)
- **nigricapita** Crawford
- **pisonia** Caldwell
- **tipicola** Caldwell

Genus **Paurotriozana** Caldwell
- **adaptata** Caldwell

Genus **Megatrioza** Crawford
- **palmicola** Crawford

Genus **Hevaheva** Kirkaldy
- **aloha** Caldwell
- **giffardi** Crawford

hyalina Crawford
maculata Caldwell
minuta Crawford
monticola Kirkaldy
perkinsi Kirkaldy
silvestris Kirkaldy
swezeyi Crawford

Genus **Crawforda** Caldwell
triopsyllina Caldwell

Genus **Swezeyana** Caldwell
elongagena Caldwell
reticulata Caldwell

Genus **Cerotrioza** Crawford
bivittata Crawford
bridwelli Crawford

Subfamily PAUROPSYLLINAE

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Species not determined

Superfamily ALEYRODOIDEA

Family ALEYRODIDAE

Subfamily ALEYRODINAE

Genus **Dialeurodes** (Cockerell)
kirkaldyi (Kotinsky)

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hibisci (Kotinsky)

Genus **Bemisia** Quaintance and Baker
giffardi (Kotinsky)

Genus **Trialeurodes** (Cockerell)
vaporariorum (Westwood)

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shizuokensis Kuwana
spiraeoides Quaintance

Superfamily APHIDOIDEA

Family APHIDIDAE

Subfamily APHIDINAE

Tribe LACHNINI

Subtribe LACHNINA

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Genus **Tuberolachnus** Mordvilko
salignus (Gmelin)

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Subtribe PHYLLAPHIDINA

Genus **Neophyllaphis** Takahashi
araucariae Takahashi

Subtribe CALLIPTERINA

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kahawaluokalani Kirkaldy

Tribe APHIDINI

Subtribe APHIDINA

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bambusae Fullaway
citricidus (Kirkaldy)
ferruginea-striata Essig
gossypii Glover
helichrysi Kaltenbach
maidis Fitch
medicaginis Koch
middletonii Thomas
rumicis Linnaeus
sacchari Zehntner

Genus **Brachycolus** Buckton
heraclei Takahashi

Genus **Brevicoryne** Van der Goot
brassicae (Linnaeus)

Genus **Cavariella** Del Guercio
aegopodii (Scopoli)

Genus **Cerosipha** Del Guercio
subterranea (Mason)

Genus **Rhopalosiphum** Koch
nymphaeae (Linnaeus)
prunifoliae (Fitch)
pseudobrassicae (Davis)

Genus **Coloradoa** Wilson
rufomaculata (Wilson)

Genus **Toxoptera** Koch
aurantii (Boyer de Fonscolombe)
cyperi Van der Goot

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caricis (Fullaway)

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sonchi (Oestlund)
vaccinii Mason

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granarium (Kirby)
rosae (Linnaeus)
rosaefolium Theobald
sanborni Gillette
solanifolii (Ashmead)

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circumflexus (Buckton)
convolvuli (Kaltenbach)
ornatus Laing
persicae (Sulzer)

Genus **Phorodon** Passerini
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violae (Pergande)

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nigronervosa Coquerel

Genus **Idiopterus** Davis
nephrelepidis Davis

Subfamily ERIOSOMATINAE

Tribe ERIOSOMATINI

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lanigera (Hausmann)

Subfamily HORMAPHINAE

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lataniae (Boisduval)

Genus **Thoracaphis** Van der Goot
fici (Takahashi)

Superfamily COCCOIDEA

Family MARGARODIDAE

Subfamily MONOPHLEBINAE

Tribe ICERYINI

Genus **Icerya** Signoret
purchasi Maskell

Family ORTHEZIIDAE

Subfamily ORTHEZIINAE

Tribe ORTHEZIINI

Genus **Orthezia** Bosc
insignis Browne

Family PSEUDOCOCCIDAE

Genus **Antonina** Signoret
bambusae (Maskell)
crawii Cockerell
graminis (Maskell)

Genus **Radicoccus** Hambleton
hawaiiensis Hambleton

Genus **Geococcus** Green
radicum Green

Genus **Phyllococcus** Ehrhorn
oahuensis (Ehrhorn)

Genus **Phenacoccus** Cockerell
gossypii Townsend and Cockerell
solani Ferris

Genus **Pedronia** Green
hawaiiensis Ferris

Genus **Clavicoccus** Ferris
erinaceus Ferris
tribulus Ferris

Genus **Pseudococcus** (Westwood)
adonidum (Linnaeus)
antricolens Ferris
boninsis (Kuwana)
brevipes (Cockerell)
citri (Risso)
citriculus Green
floriger Ferris
gallicola Ehrhorn
giffardi (Ehrhorn)

maritimus (Ehrhorn)
mendiculus Ferris
montanus Ehrhorn
nipae (Maskell)
nudus Ferris
palmarum (Ehrhorn)
straussiae Ehrhorn
swezeyi Ehrhorn
tympanistus Ferris
vastator (Maskell)

Genus **Trionymus** Berg
insularis Ehrhorn
lounsburyi Brain
refertus Ferris
sacchari (Cockerell)

Genus **Ferrisiana** Takahashi
virgata (Cockerell)

Genus **Nesococcus** Ehrhorn
pipturi Ehrhorn

Family ASTEROLECANIIDAE

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Genus **Asterolecanium** Targioni-Tozzetti
bambusae (Boisduval)
miliaris miliaris (Boisduval)
pustulans (Cockerell)
scirrosis Russell

Family KERMIDAE

Genus **Eriococcus** Targioni-Tozzetti
araucariae Maskell
coccineus Cockerell

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Genus **Coccus** Linnaeus
acuminatus (Signoret)
acutissimus (Green)

elongatus (Signoret)
hesperidum Linnaeus
mangiferae (Green)
pseudohesperidum (Cockerell)
viridis (Green)

Genus **Eucalymnatus** Cockerell
tessellatus (Signoret)

Genus **Saissetia** Déplanche
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nigra (Nietner)
oleae (Bernard)

Genus **Pulvinaria** Targioni-Tozzetti
mammeae Maskell
psidii Maskell
urbicola Cockerell

Genus **Ceroplastes** Gray
rubens Maskell

Family DIASPIDIDAE

Subfamily DIASPIDINAE

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tesseratus (de Charmoy)

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hederae (Vallot)
spinosus Comstock

Genus **Morganella** Cockerell
longispina (Morgan)

Genus **Hemiberlesia** Leonardi
cyanophylli (Signoret)
lataniae (Signoret)
rapax (Comstock)

Genus **Aonidiella** Berlese and Leonardi
inornata McKenzie

Genus **Furcaspis** Lindinger
biformis (Cockerell)

Genus **Lindingaspis** MacGillivray
rossi (Maskell)

Genus **Chrysomphalus** Ashmead
bifasciculatus Ferris
dictyospermi (Morgan)
ficus Ashmead
propsimus Banks

Tribe DIASPIDINI

Genus **Leucodiaspis** Signoret
cockerelli (de Charmoy)

Genus **Fiorinia** Targioni-Tozzetti
fioriniae (Targioni-Tozzetti)
nephelii Maskell

Genus **Aulacaspis** Cockerell
fulleri (Cockerell)
rosae (Bouché)

Genus **Pseudaulacaspis** MacGillivray
major (Cockerell)

Genus **Phenacaspis** Cooley and Cockerell
sandwicensis (Fullaway)

Genus **Pinnaspis** Cockerell
aspidistrae (Signoret)
buxi (Bouché)
strachani (Cooley)
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pseudaspidiotus (Lindinger)

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pergandei Comstock
proteus (Curtis)
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longirostris (Signoret)

Genus **Andaspis** MacGillivray
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Genus **Howardia** Berlese and Leonardi
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pseudoleucaspis (Kuwana)

Genus **Diaspis** Costa
boisduvalii Signoret
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echinocacti (Bouché)

Genus **Lepidosaphes** Shimer
beckii (Newman)
gloverii (Packard)
mackieana McKenzie
noxia McKenzie
pallida (Maskell)
tokionis (Kuwana)

Tribe ODONASPIDINI

Genus **Odonaspis** Leonardi
greenii (Cockerell)
ruthae Kotinsky

Subfamily PHOENICOCOCCINAE

Tribe PHOENICOCOCCINI

Genus **Palmaricoccus** Stickney
nesiotes (Laing)
pritchardiae Stickney

Genus **Platycoccus** Stickney
tylocephalus Stickney

Suborder **HOMOPTERA**, continued

Series STERNORHYNCHA Amyot and Serville, 1843

Hymenelytra Latreille, 1825, in part.

Phytophthires Burmeister, 1835.

This subdivision contains the most divergent of the Hemiptera and includes many highly modified forms. The adults have the tarsi one- or two-segmented, and the wing venation is greatly reduced. The group includes many wingless and immobile forms.

Key to the Superfamilies

1. Tarsi one-segmented (rarely two-segmented), with only one claw; females sometimes legless, often covered with a scale or with waxy exudation, always apterous, often immobile, scale-like, gall-like or with a powdery exudation or a waxy or cottony filamentation; males usually with two long, caudal filaments, and, if winged, with only fore wings developed, and these lying overlapped and flat over abdomen when at rest .... **Coccoidea.**
   Tarsi two-segmented, with two claws; adults active, free-living insects 2

2(1). Antennae nine- to ten-segmented; veins of fore wings arising as branches of a charcteristic basal median stem; actively leaping forms .... **Psylloidea.**
   Antennae with seven or fewer segments; not active leaping forms 3

3(2). Wings opaque and covered with a white powdery exudation, without a stigma; antennae seven-segmented..... .... **Aleyrodoidea.**
   Wings hyaline and not covered with an exudation, with a distinct stigma; fifth tergite usually with a pair of cornicles; antennae three- to six-segmented....... **Aphidoidea.**

Superfamily PSYLLOIDEA

Chermoidea Essig, 1942:320.

Only one family is included in this group.

Family **PSYLLIDAE** Latreille, 1807

Psyllids, Jumping Plant Lice

The psyllids resemble miniature cicadas in general form, but the adults are endowed with prodigious leaping powers. In our fauna they may be confused with the aphids or aleyrodids, some are easily mistaken for psocids, and the nymphs are not infrequently taken for coccids. Their saltatorial ability in combination with their usually 10-segmented antennae and their characteristic wing venation (see the illustrations) form a set of characters which will distinguish them adequately here. The hind legs, although capable of great leaping powers, are not as enlarged as the literature would lead one to expect. There are three ocelli, the rostrum arises far back on the sternum, the tarsi are two-segmented, and the fore wings are larger and usually stiffer than the hind pair. In the fore wings the radius, media and cubitus are fused basad to form a single basal stalk-like vein, and cross-veins are wanting (although one of our *Swezeyana* species has pseudo-cross-veins between Rs and the wing margin). The fore wings may be clear, opaque, tinged, clouded, maculate or mostly or entirely dark-colored. The hind wings are frequently reduced or much abbreviated; their normal complement of veins consists of Rs, unforked M, and Cu, Cu_1 and Cu_2.

Almost nothing is known regarding the eggs of the Hawaiian species, but elsewhere some species insert their eggs in plant tissues, others deposit them on the surface of the host and these are usually supported by short or elongate stalks.

The nymphs live either free or in galls on leaves, buds or twigs of the hosts, which in Hawaii are all shrubs and trees. They differ considerably among the species and many have most useful differential characters. Some species are more distinctive as nymphs than as adults, and closely allied forms may have distinct habits in the nymphal state. There are five instars, and considerable change in form may take place between the instars. The last instar nymphs are nearly circular and quite flat in some species. The surface and/or margins of the body may have numerous setae and modified seta-like processes (sectisetae), and may produce quantities of wax from the sectisetae which add to the decoration of the body. Some forms produce an abundance of honeydew and many secrete large amounts of wax. Some of the Australian species, there called lerp insects, produce such copious amounts of honeydew that they long have been utilized, like manna by the native Australians.

The nymphs of some species live free on their hosts, some live in slight depressions, whereas others produce various types of galls. Some of our species occur in great numbers and are especially abundant on *Metrosideros* and *Pelea,* on which trees they produce vast numbers of galls.

All the species occurring in Hawaii are, so far as is known, endemic insects, and none is of economic importance. In other regions, however, there are species such as the potato, apple, pear, olive, citrus, orange, carrot, eucalyptus, camphor, acacia, fig and indigo psyllids and others which are of importance to agriculture. Some kinds are involved in the transmission of certain plant diseases.

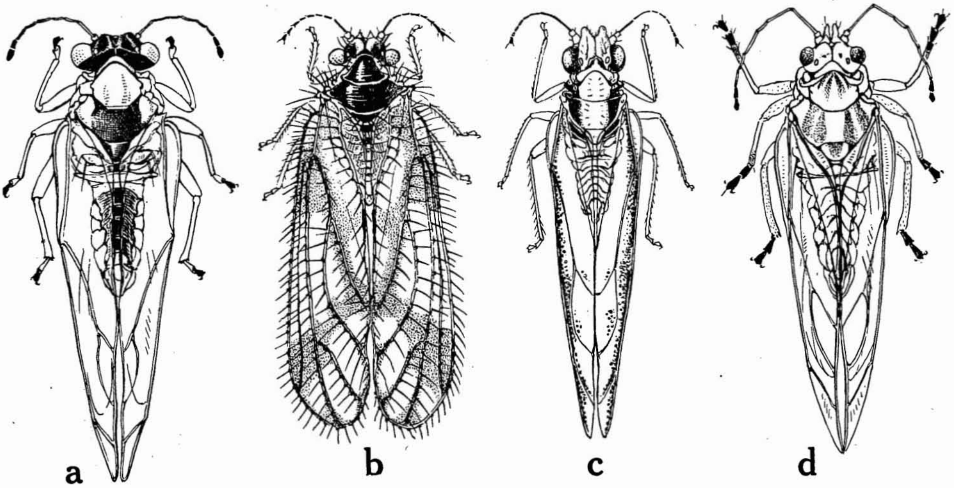


Figure 1—Some Hawaiian Psyllidae: **a,** *Kuwayama nigricapita* Crawford; **b,** *Hevaheva giffardi* Crawford; **c,** *Cerotrioza bivittata* Crawford; **d,** *Trioza hawaiiensis* Crawford. (Abernathy drawings.)

Only three workers have described the Hawaiian species. A few were worked up by Kirkaldy, the largest number was described by Crawford, and Caldwell has lately described some more recently collected, especially distinct forms. The bulk of the field work on the group has been done by Swezey.

Much remains to be done on the Hawaiian psyllids, and I feel that hardly more than a preliminary survey has been made thus far. In my brief studies of the group, I have found that there are a number of new species in local collections and that a detailed survey of the family, with adequate attention given to field studies, by a trained worker would yield a wealth of new data and that the number of species would be materially increased. A most profitable and interesting field lies open in research in the bionomics of these attractive insects, and we may look forward to the future assembling of large amounts of new information.

Subfamily TRIOZINAE Loew, 1879

With the exception of the single record of a *Paurocephala* which is discussed below, the Hawaiian psyllids belong to only one of the subfamilies of Psyllidae. The subfamilies Carsidarinae, Psyllinae and Liviinae do not appear to be represented in our fauna. The other subfamily, the Pauropsyllinae, is represented by an undescribed species known from a single example.

It appears that only a few ancestral immigrant forms gave rise to our psyllid fauna. In fact, most of the species probably have arisen from a single ancestral immigrant.

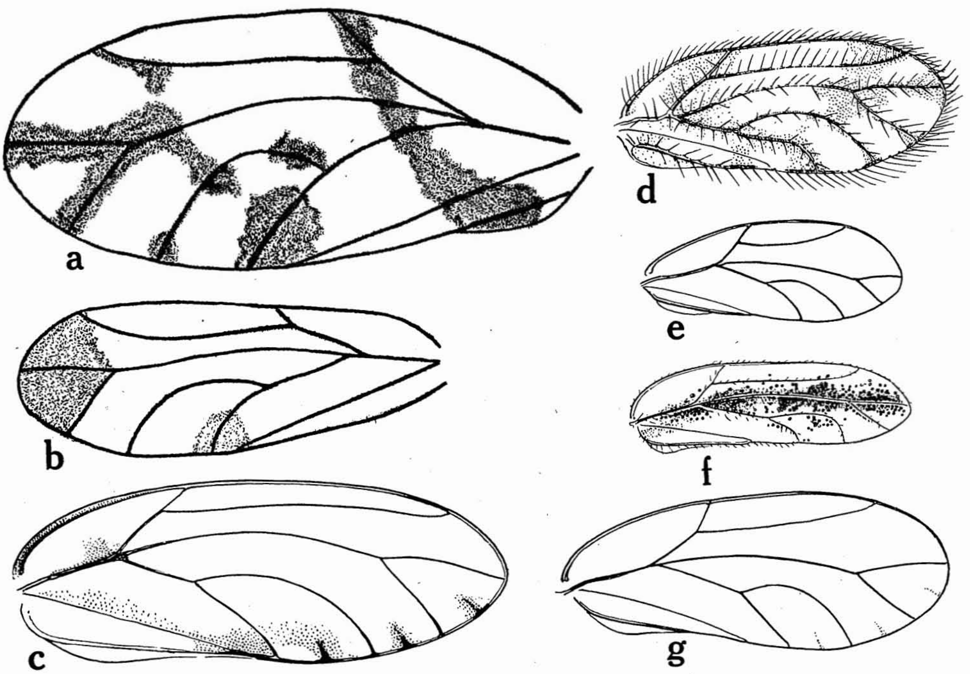


Figure 2—Tegmina of Psyllidae: **a,** *Hevaheva monticola* Kirkaldy, setae omitted; **b,** *Hevaheva swezeyi* Crawford, setae omitted; **c,** *Megatrioza palmicola* Crawford; **d,** *Hevaheva giffardi* Crawford; **e,** *Kuwayama nigricapita* Crawford; **f,** *Cerotrioza bivittata* Crawford; **g,** *Trioza hawaiiensis* Crawford. (**c–g,** drawn by Abernathy.)

Key to the Genera of Hawaiian Psyllidae

(See also the key by Caldwell, 1940:389.)

1. Venation of fore wing as in figure 3, d, media and cubitus arising from a common stalk and far removed from origin of radius........................**Paurocephala** Crawford.
   Venation obviously different........................... 2

2(1). Vertex of head with a horn-like protuberance on either side of median line at a level near tops of antennal insertions which project forward beyond fore edges of antennal bases (do not confuse antennal bases with genal cones, which are rather similar processes on other genera but absent on this one, and which arise *below* the level of the antennae, and do not confuse with the usual normal lobes of the vertex)................ **Cerotrioza** Crawford.

Vertex without such processes.......................... 3

3(2). Veins of fore wings with conspicuous, erect, usually long, bristling setae (but if indistinct, as in the very pale *Hevaheva minuta,* then the genal cones are present and the fore wings lack the hind marginal spots—which characters will serve to separate the species from *Trioza* or *Kuwayama,* to which they would otherwise run)........ .... **Hevaheva** Kirkaldy.

Wing veins without such setae (if setae are present, they are microscopic) 4

4(3). Radius of fore wings indistinct, obscure or obsolete beyond origin of radial sector, thus not continued distinctly to wing margin as normally developed in other groups; genal cones very long, longer than length of vertex by a quarter or a third, and longer than interocular distance of vertex.......................... **Swezeyana** Caldwell.

Radius normally developed and continued directly out to wing margin; genal cones not so elongated............. 5

5(4). Fore wing with bases of radius and media lying very close together or merged so that these veins arise from a short, common stalk which separates them from place of origin of cubitus (fig. 7)........part of **Trioza** Foerster.

Fore wings with radius, media and cubitus arising from a common point 6

6(5). Fore wings with radius longitudinally confluent with wing margin so that wing margin is much thicker at and distad of point where radius joins it than basad of this position (thus forming a "pterostigma")................ .... **Crawforda** Caldwell.

Radius of fore wing joining wing margin directly and not causing latter to be broader distad (thus the wing has no "pterostigma")................................... 7

7(6). Each hind tibia with a tooth-like process on basal swelling of outer side near articulation with femur ("basal spur") .... **Megatrioza** Crawford.

Hind tibiae without such processes..................... 8

8(7). Fore wings entirely infumate......... **Paurotriozana** Caldwell.

Fore wings clear, not colored.......................... 9

9(8). Genal cones present (low and boss-like in some forms, however)............................. **Trioza** Foerster.

Genal cones absent or obsolete......... **Kuwayama** Crawford.

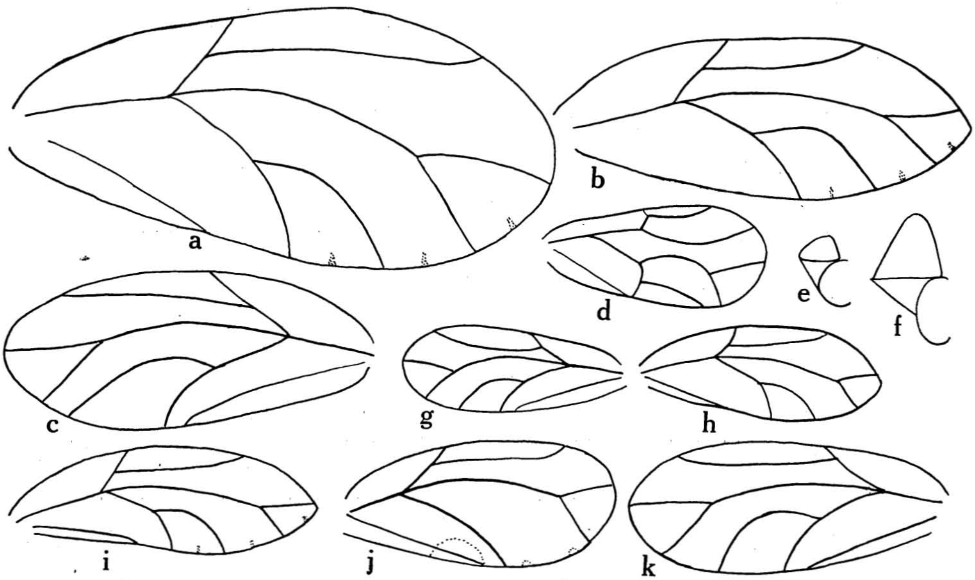


Figure 3—Features of some Psyllidae: **a,** tegmen of holotype of *Trioza kauaiensis* Crawford, drawn to same scale as *T. lehua* (i); **b,** tegmen of *Trioza ohiacola* Crawford, anal vein omitted; **c,** *Hevaheva perkinsi* Kirkaldy, setae omitted; **d,** tegmen of *Paurocephala* species from Molokai; **e,** right genal cone of *Trioza lehua* Crawford, holotype; **f,** right genal cone of *Trioza ohiacola* Crawford, holotype, to show comparative development; **g,** tegmen of a female of *Hevaheva minuta* Crawford from the type series, and similar to the female type, setae omitted; **h,** tegmen of male holotype of *Hevaheva minuta* Crawford, setae omitted, to show variation in venation (compare **g**); **i,** tegmen of *Trioza lehua* Crawford, holotype; **j,** tegmen of *Hevaheva silvestris* Kirkaldy, setae omitted (areas surrounded by dotted lines are pale spots); **k,** tegmen of holotype of *Hevaheva hyalina* Crawford, setae omitted.

Genus **TRIOZA** Foerster, 1848

For synonymy, see Tuthill, 1943:546.

This is an almost cosmopolitan genus and is well represented in the Indo-Pacific regions. It is one of the largest groups of the family in Hawaii, and from it apparently has sprung the bulk of the other genera found here.

The species have genal cones which are developed to a varying extent among the species; the fore wings are clear, the veins do not have such conspicuous erect setae as do those of *Hevaheva* (although they are finely setose), they are of normal form and do not have such specializations as a pterostigma or a radius which becomes obsolete beyond the radial sector as do those of certain of our other genera; the vertex of the head lacks the horn-like protuberances as found on *Cerotrioza;* the hind tibiae, although they may be swollen at the base, are not armed there with a dentiform process as are those of *Megatrioza,* but the callus is finely asperate in some species.

It is probable that all our species have arisen from a single ancestral Polynesian immigrant.

It appears to me that much taxonomic work remains to be done with this genus in the Hawaiian Islands. The species, as they are interpreted now, are mostly closely allied to one another and their differentiation is not easy. More detailed descriptive work is needed, the genitalia of all need careful study, and the life histories of the species are poorly and inadequately known. The group is in a state of evolutionary flux and most of the "species" have reached a state of only slight differentiation. Crawford's diagnoses are not altogether accurate or are misleading in some respects. A revision of the group is desired, but the task will be a difficult one, for there is much confusing variation among the species.

The usual hostplant for the group in Hawaii is the Pacific myrtaceous genus *Metrosideros,* upon the leaves and stems and buds of which galls are formed, but some species attack other plants.

Key to the Hawaiian Trioza

(See also Crawford's key, 1918:440.)

1. Fore wings with bases of radius and media lying very close together or merged so that these veins arise from a short, common stalk which separates them from place of origin of cubitus (see fig. 7) .... **uniqua** (Caldwell).
   Fore wings with radius, media and cubitus arising from a common point 2

2(1). Genal cones short or very short, shorter or hardly longer on their outer sides than diameter of an antennal socket, blunt and boss-like in some forms 3
   Genal cones elongate, tapering, distinctly longer than diameter of an antennal socket 5

3(2). Media of fore wing forking at a point on or basad of a line drawn obliquely across wing from apex of Rs and apex of Cu_1; a large species with broadly rounded fore-wing apices (fore wing as in fig. 3, a) .... **kauaiensis** Crawford.
   Media of fore wing forking distad of a line drawn between apices of veins Rs and Cu_1; fore wings moderately pointed distad, as in figure 3, i 4

4(3). Antennae only about as long as breadth of head across eyes; pale-colored species, largely pale yellow or greenish-yellow, legs pale; genal cones very short, as in figure 3, e; fore wing 2 mm. or less in length; Kauai........ .... **lehua** Crawford.
   Antennae much longer than breadth of head across eyes; darker-colored species, usually largely brown, reddish-brown or dark brown; genal cones larger, formed as in figure 3, f, or more sharply pointed; fore wings usually 2.25 mm. long or longer............... **ohiacola** Crawford.

5(2). A line drawn between apex of Rs and apex of Cu_1 passes distinctly basad of fork of M........................ 6
   Such a line passes through angle of the fork of M......... 7

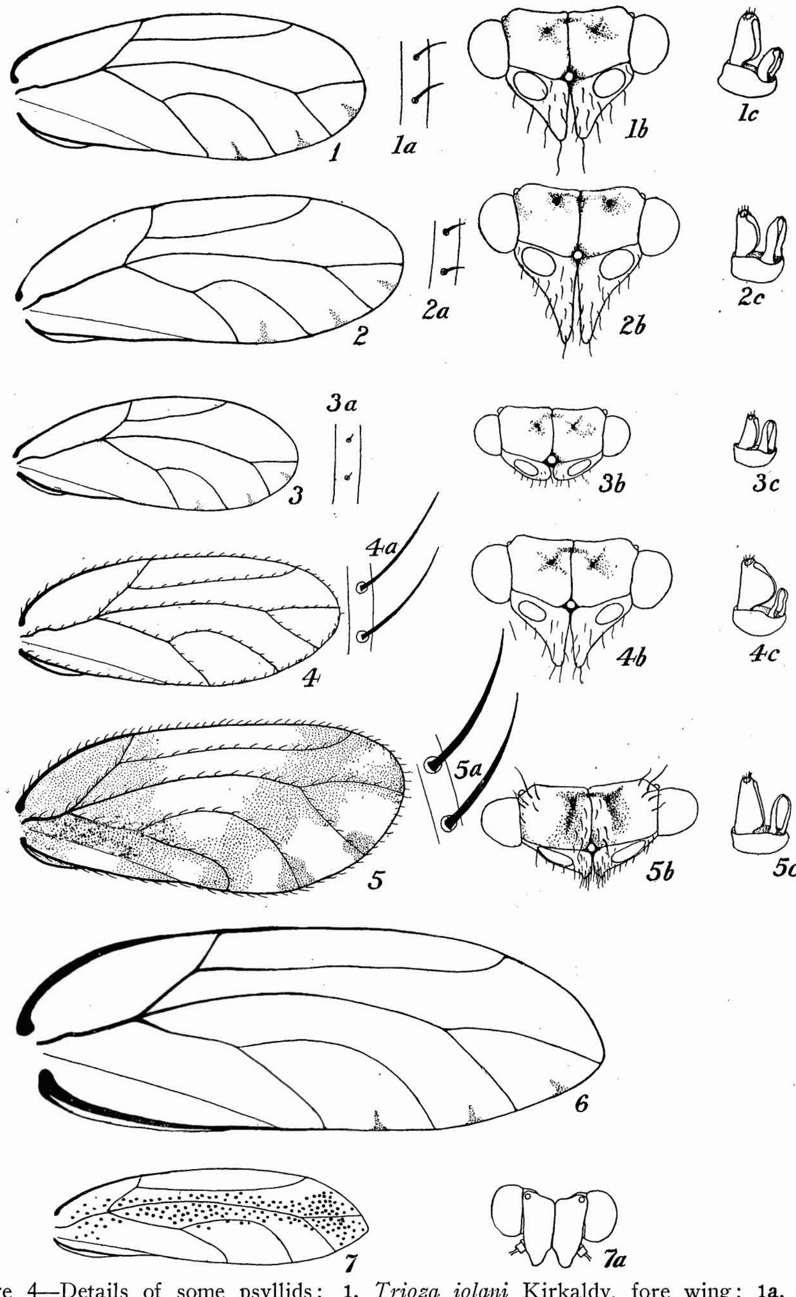


Figure 4—Details of some psyllids: **1**, *Trioza iolani* Kirkaldy, fore wing; **1a**, marginal setae of fore wing; **1b**, frontal view of head; **1c**, male terminalia. **2**, *Trioza lanaiensis* Crawford, fore wing; **2a–2c**, same views as in **1**. **3**, *Kuwayama nigricapita* Crawford, same views as in **1** and drawn to same scale. **4**, *Hevaheva perkinsi* Kirkaldy, same views as **1** and drawn to same scale. **5**, *Hevaheva giffardi* Crawford, same views as **1** and drawn to same scale. **6**, *Megatrioza palmicola* Crawford, fore wing drawn to same scale as others. **7**, *Cerotrioza bivittata* Crawford, fore wing, and **7a**, dorsal view of head to show processes of vertex, genae not visible. (After Crawford, 1918.)

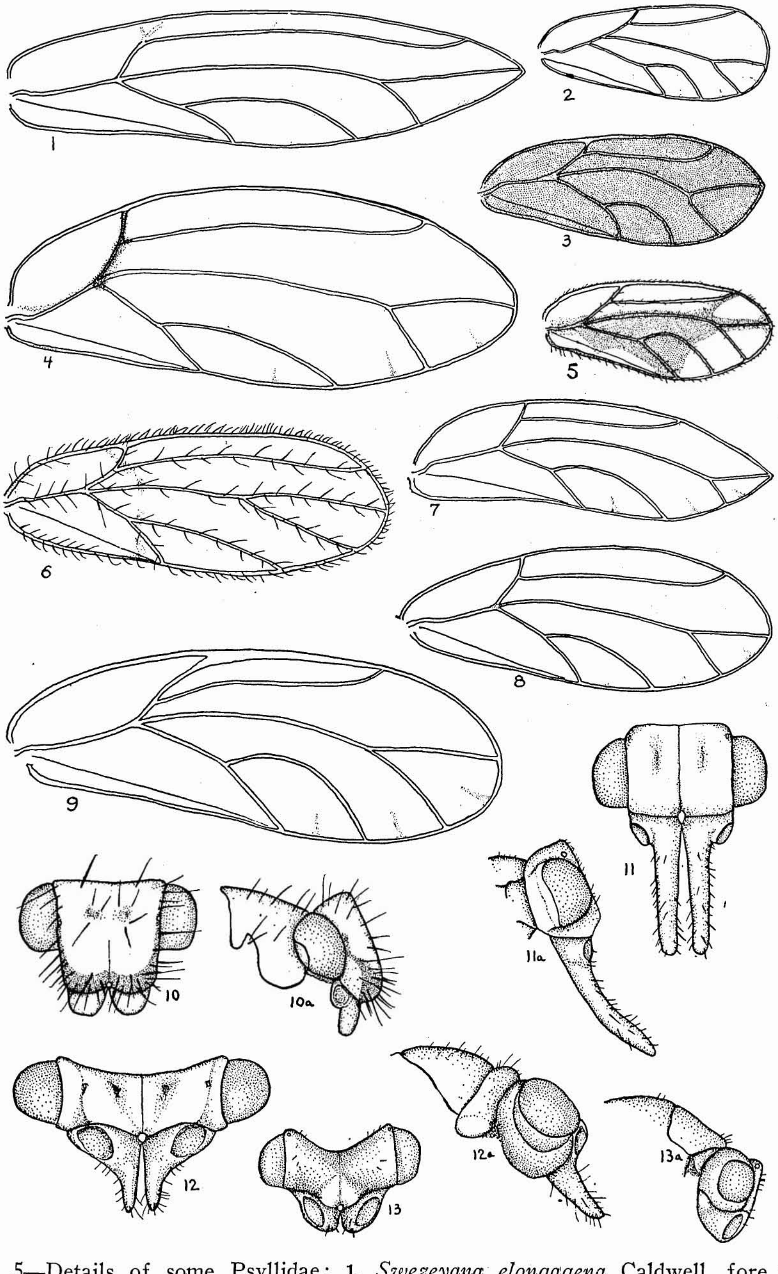


Figure 5—Details of some Psyllidae: **1**, *Swezeyana elongagena* Caldwell, fore wing; **2**, *Trioza uniqua* (Caldwell), fore wing; **3**, *Paurotriozana adaptata* Caldwell, fore wing; **4**, *Kuwayama pisonia* Caldwell, fore wing; **5**, *Hevaheva maculata* Caldwell, fore wing; **6**, *Hevaheva aloha* Caldwell, fore wing; **7**, *Kuwayama tipicola* Caldwell, fore wing; **8**, *Kuwayama minutura* (Caldwell); **9**, *Crawforda triopsyllina* Caldwell, fore wing; **10**, *Hevaheva aloha* Caldwell, frontal view of head, and **10a**, profile of head and thorax; **11**, **11a**, *Swezeyana elongagena* Caldwell, same views as **10**, **10a**; **12**, **12a**, *Crawforda triopsyllina* Crawford, same views as above; **13**, **13a**, *Paurotriozana adaptata* Caldwell, same views as above. (After Caldwell, 1940.)

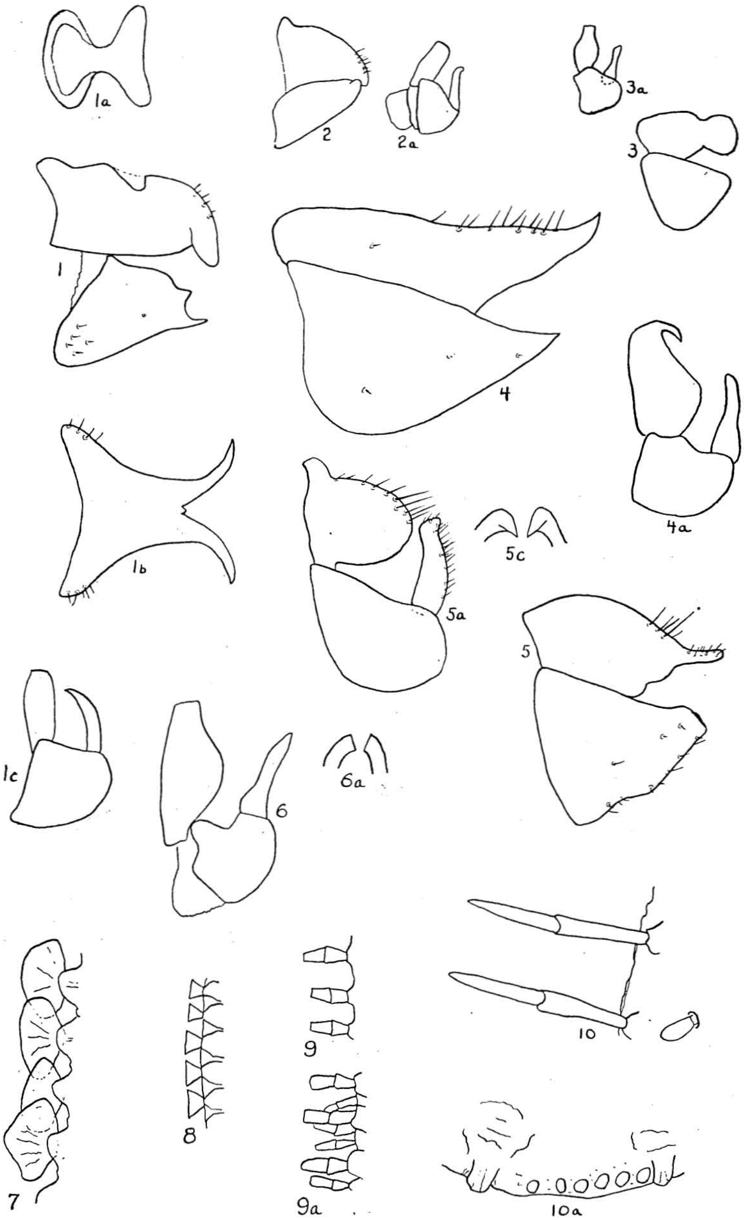


Figure 6—Details of some nymphs and adult terminalia of some psyllids: **1,** *Swezeyana elongagena* Caldwell, profile of female terminalia; **1a,** dorsal view of circumanal ring; ventral view of ventral valve of female at **1b,** and profile of male terminalia at **1c.** **2,** *Hevaheva maculata* Caldwell, profile of female genitalia, and profile of male terminalia at **2a.** **3, 3a,** the same views of *Trioza uniqua* (Caldwell). **4, 4a,** the same of *Crawforda triopsyllina* Caldwell. **5, 5a,** the same of *Kuwayama pisonia* Caldwell, with caudal view of male forceps at **5c.** **6,** *Hevaheva aloha* Caldwell, profile of male terminalia, with caudal view of male forceps at **6a.** **7,** *Swezeyana elongagena* Caldwell, marginal sectisetae of nymph. **8,** *Kuwayama pisonia* Caldwell, marginal sectisetae of nymph. **9,** *Kuwayama tipicola* Caldwell, marginal sectisetae on thorax of nymph, with sectisetae of abdomen at **9a.** **10,** *Crawforda triopsyllina* Crawford, marginal sectisetae of thorax of nymph, with abdominal glands and tubes at **10a.** (After Caldwell, 1940.)

6(5). Thorax typically yellow or greenish with vague or distinct brown vittae; antennae more than twice as long as breadth of head across eyes (see discussion under *molokaiensis*)..... **lanaiensis** Crawford; **molokaiensis** Crawford.
A darker species, mostly dark brown; antennae about twice as long as breadth of head across eyes or somewhat shorter.......................... **pullata** Crawford.
7(5). Costal margin of fore wings with a distinct fringe of setae extending all the way to apex, the setae comparatively dense and about as long as breadth of costa; Oahu... .... **iolani** Kirkaldy.
Setae of costal margin of fore wing short, sparse and generally inconspicuous, almost absent beyond radius; Hawaii and Lanai................................ 8
8(7). Lanai species........................ **lanaiensis** Crawford.
Hawaii species...................... **hawaiiensis** Crawford.

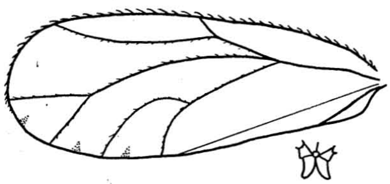


Figure 7—*Trioza uniqua* (Caldwell), paratype; fore wing and genal cones.

Trioza hawaiiensis Crawford (figs. 1, d; 2, g).
Trioza hawaiiensis Crawford, 1918:444.

Endemic. Hawaii (type locality: Kilauea, 4,000 feet).
Hostplant: *Metrosideros.*
The holotype, its abdomen missing, is in the Experiment Station, Hawaiian Sugar Planters' Association. See the comments under *molokaiensis.*

Trioza iolani Kirkaldy (figs. 4, 8).
Trioza iolani Kirkaldy, 1902:114, pl. 4, fig. 2; 1908:206. Crawford, 1918:441, pl. 8, figs. 1, a–c.

Endemic. Kauai (type locality: Halemanu), Oahu, Maui.
Hostplant: *Metrosideros polymorpha;* forms galls on the leaves.
Parasite: Timberlake (*Proc. Hawaiian Ent. Soc.* 3(4):281, 1917) reported breeding a "Eulophine thought to be near the genus *Sympiesis*" from the galls.
The holotype should be in the British Museum.
There may be some confusion regarding the identity of this species. It is generally thought of as one of the commonest psyllids on Oahu. Yet the holotype was designated as a Kauai specimen. The record from Maui is based upon a single

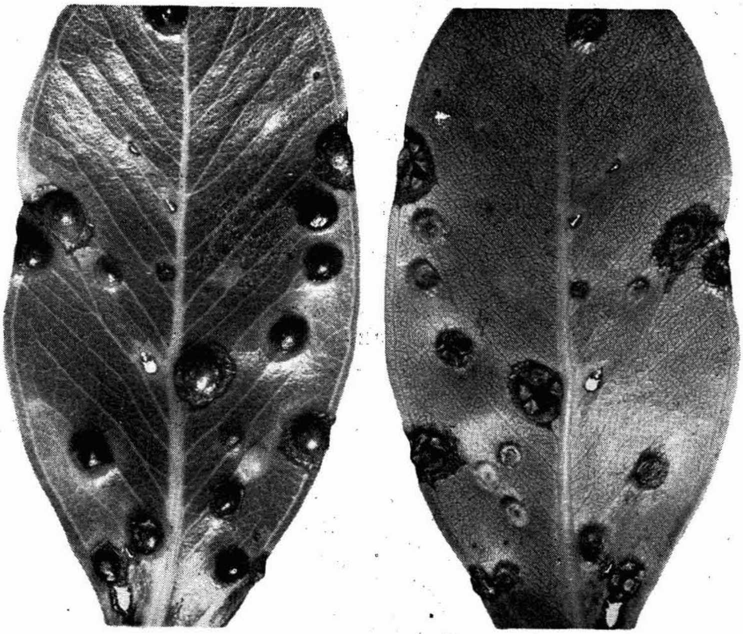


Figure 8—Galls of *Trioza iolani* Kirkaldy on leaf of *Metrosideros polymorpha* from Oahu; left, dorsal view; right, ventral view.

example. Further study might reveal that the Oahu form is a distinct species from the Kauai form and thus really needs a new name, and that the Maui example belongs to another form. The problem needs investigation.

Trioza kauaiensis Crawford (fig. 3, a).
Trioza kauaiensis Crawford, 1925:29.

Endemic. Kauai (type locality: Kokee).
Hostplant: *Metrosideros* [*Myrsine* (*Suttonia*), *Dodonaea*, accidental captures?].
The type is in the Experiment Station, Hawaiian Sugar Planters' Association.

Trioza lanaiensis Crawford (fig. 4).
Trioza lanaiensis Crawford, 1918:443, pl. 8, figs. 2, 2a–c.

Endemic. Lanai (type locality: 3,400 feet), Molokai.
Hostplant: *Metrosideros*.
The type, which lacks fore wings, is in the Experiment Station, Hawaiian Sugar Planters' Association.

"This appears to be an incipient, not yet clearly marked, species developing from the Oahuan species, *T. iolani*." (Crawford, 1918:443.) See my notes under *molokaiensis*.

Trioza lehua Crawford (fig. 3, e, i).
Trioza lehua Crawford, 1925:29.

Endemic. Kauai (type locality: Nualolo).

Hostplant: *Metrosideros.*

The holotype is in the Experiment Station, Hawaiian Sugar Planters' Association.

Trioza molokaiensis Crawford.
Trioza molokaiensis Crawford, 1927:423.

Endemic. Molokai (type locality: Kamiloloa).

Hostplant: *Metrosideros,* (*Coprosma,* error in record or accidental captures ?).

The type is in the Bishop Museum.

I have not been able to separate this species satisfactorily from *lanaiensis,* and *hawaiiensis* is not clearly distinct. These three forms are closely allied and each is variable. Their status needs clarification, but I am unable to do more now than to point out the problem and leave it for some future specialist.

Trioza pullata Crawford.
Trioza pullata Crawford, 1918:444.

Endemic. Lanai (type locality: Waiopaa, west side).

The holotype is in the Experiment Station, Hawaiian Sugar Planters' Association.

This form is closely allied to *lanaiensis.* When the two are compared, it is evident that *pullata* is a much darker insect with the dorsum more coarsely reticulate.

Trioza ohiacola Crawford (fig. 3, b, f).
Trioza ohiacola Crawford, 1918:442.

Endemic. Oahu (type locality: Mount Kaala), Maui, Hawaii (probably also on Molokai and Lanai).

Hostplant: *Metrosideros* (galls recorded on the leaves of *Metrosideros glaberrima*).

The holotype is in the Experiment Station, Hawaiian Sugar Planters' Association.

This species and *iolani* were considered by Crawford to be close to the original immigrant ancestral *Trioza.* It is a common, abundant species. It tends to blend into *iolani,* is quite variable and is known to be more widespread than the other species.

Crawford (1925:27) examined a series of "atypical" examples bred from galls on the stems and buds of *Metrosideros,* instead of from leaf galls. Perhaps this change of food habit indicates the rise of a new form.

Trioza uniqua (Caldwell), new combination (figs. 5, 6, 7).

Ceropsylla uniqua Caldwell, 1940:392, pl. 22, fig. 2; pl. 23, figs. 3, 3a.

Endemic. Kauai (type locality: trail from Kokee to Kalalau).

Hostplant: *Cryptocarya.*

This is a small, delicate species (fore-wing length, 1.5–2.0 mm.) which resembles one of the small species of *Kuwayama,* but the genal cones are well developed. The fore wings have a slight yellowish tinge and are immaculate except for a small, rather obscure dark mark on the anal vein. The head and thoracic nota are black or nearly so, whereas the appendages and abdomen are largely yellowish.

This species was placed in *Ceropsylla* Riley (whose genotype is the North American *sideroxyli* Riley) by Caldwell. From his statement "At the present there seems to be no other deposition for this species than *Ceropsylla,*" it is clear that he was uncertain as to the generic position of the species. The species does not belong to *Ceropsylla,* and I believe that too much emphasis was placed on the courses of the fore-wing veins, which tend to parallel the development of those of *Ceropsylla* without this species being an ally of that genus. The fusion of the origins of R and M to form a short stalk beyond the origin of Cu appears to me to be subject to some variation in *uniqua.* The small spots along the hind margin in the cells of the fore wings are typical of our *Trioza.* If the species is removed from *Trioza,* then a very weak new genus would have to be erected for it.

Genus **KUWAYAMA** Crawford, 1911

Epitrioza Crawford, 1911.

The genotype of *Kuwayama* is *medicaginis* (Crawford), a North American insect. Our species assigned to the genus are not of similar origin, but have originated locally from one or more Hawaiian species of the allied genus *Trioza.* Crawford (1924:370) says, "This genus is distinguished from *Trioza* by the absence of genal cones. . . . The fact that several species from widely separated regions have been referred to this genus and the further fact that each of these species appears to be more closely related to certain *Trioza* species in the same region than to other *Kuwayama* species elsewhere, would seem to indicate that the absence of genal cones is a characteristic derived independently in different localities as parallel evolutional development." He has noted further that certain examples of Hawaiian species tend to revert to the *Trioza* type by having abnormally developed genal cones. There is much variation in the development of the genal cones among our species of *Trioza,* for some species have the cones long and prominent, whereas others have them reduced to small protuberances, and the student may be confused as to which genus certain species should be assigned.

It is peculiar that the three species described by Crawford are closely allied, *Metrosideros*-inhabiting forms, whereas the three described by Caldwell are divergent species of different habit and living on different hosts.

Key to the Hawaiian Species of Kuwayama

(See also the key to species by Crawford, 1918:446.)

1. A line drawn across fore wing between apex of Rs and Cu_1 passes through or very nearly through angle of origin of fork of M 2
   Such a line passes distinctly basad of fork of M 3

2(1). Hind wings extending back only to a point about half way between Cu_2 and Cu_1 on fore wings; radius of fore wings and adjacent membrane conspicuously dark colored; the largest species of the genus, fore-wing length 3.5–4.2 mm. .... **pisonia** Caldwell.
   Hind wings longer, extending back to apex of Cu_1 on fore wings; radius and adjacent membrane on fore wings little if any darker than other veins; fore-wing length 2.5–2.7 mm. .... **minutura** (Caldwell).

3(2). Fore wings conspicuously pointed at apex, as in figure 5 .. .. **tipicola** Caldwell.
   Fore wings rounded at apex, *not* as in figure 5 of *tipicola* .. 4

4(3). A conspicuously dark-colored species, body (appendages excepted) almost entirely dark brown .... **gracilis** Crawford.
   Body largely or entirely pale, although head and part of dorsum may be dark 5

5(4). A bicolored species; typically the head is very dark, and median part of nota excluding prescutum of mesonotum is brown or black, whereas the body is elsewhere mostly pale colored and the dark and pale areas are in sharp contrast (sometimes the dark color is confined to the head) .... **nigricapita** Crawford.
   Head and entire body uniformly yellowish or brownish-yellow, not bicolored above .... **minuta** Crawford.

Kuwayama gracilis Crawford.

Kuwayama gracilis Crawford, 1918:447.

Endemic. Oahu (type locality: Kuliouou), Molokai, Maui.

Hostplant: *Metrosideros*, (*Pipturus* and *Coprosma*, stray captures ?).

The holotype is in the Experiment Station, Hawaiian Sugar Planters' Association.

It is not altogether certain that all the assembled specimens called *gracilis* in our collections belong to the same species. Crawford notes that there is a tendency for specimens from various localities to develop genal cones and revert to the *Trioza* type.

Kuwayama minuta Crawford.
Kuwayama minuta Crawford, 1918:447.

Endemic. Kauai, Hawaii (type locality: Kilauea).
Hostplant: *Metrosideros.*
The holotype is in the Experiment Station, Hawaiian Sugar Planters' Association.
The nymphs live free upon the leaves of the hostplant. The known distribution is unnatural. Perhaps the Kauai record belongs to a distinct species.

Kuwayama minutura (Caldwell), new combination (fig. 5).
Kuwayama pisonia variety *minutura* Caldwell, 1940:391, pl. 22, fig. 8.

Endemic. Oahu (type locality: Haleauau Valley, Waianae Mountains).
Hostplant: *Pisonia sandwicensis.*
The types are in the Experiment Station, Hawaiian Sugar Planters' Association.
I have chosen to elevate this form to full specific rank. Both *pisonia* and *minutura* occur in the same region, but they have not been taken together, either one form or the other has been collected on various trips to the region, but not both at the same time. They are closely related, however, although they can be separated easily.
Dr. Swezey has given me the following information on the nymphs: "In shallow pits 1 mm. in diameter on upper surface of leaf, surrounded by a slight thickened area of leaf 5–6 mm. in diameter, under side of leaf slightly convex at these areas."
Caldwell (1940:391–392) notes of the two forms that the "greatly swollen genae . . . suggests a close relationship with *Trioza,* on the other hand the nymph suggests relationship to *Ceropsylla.*" The *Trioza* affinities are true, but the *Ceropsylla* tendency is superficial, if it does exist.

Kuwayama nigricapita Crawford (figs. 1, a; 2, e; 4).
Kuwayama nigricapita Crawford, 1918:446, pl. 8, figs. 3, 3a–c.

Endemic. Molokai, Lanai, Hawaii (type locality: Niulii).
Hostplant: *Metrosideros.*
The holotype is in the Experiment Station, Hawaiian Sugar Planters' Association.
In some localities the specimens tend to be more extensively dark than in other places, but in the typical bicolored form the insect is a pretty and rather striking species.
The nymphs live free on the leaves. The single example examined by me bristles over-all with white, setae-like, wax filaments.
I have seen a new species from Oahu recently collected by Swezey which is closely similar but distinct.

Kuwayama pisonia Caldwell (figs. 5, 6, 9, 10).
Kuwayama pisonia Caldwell, 1940:391, pl. 22, fig. 4; pl. 23, figs. 5, 5a–c, 8.

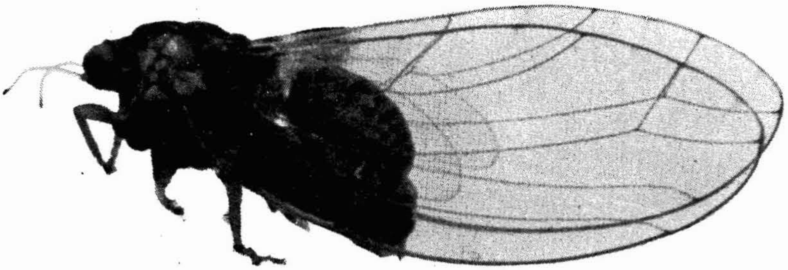


Figure 9—*Kuwayama pisonia* Caldwell, female.

Endemic. Oahu (type locality: Halona Valley, Waianae Mountains).
Hostplant: *Pisonia sandwicensis.*
The types are in the Experiment Station, Hawaiian Sugar Planters' Association.
This is the largest member of the genus in Hawaii and is one of the larger Hawaiian psyllids. It appears out of place with most of the other species, which are small creatures. The nymph is described by Caldwell. Dr. Swezey supplies the following information from his field notebook: "Galls numerous on undersides of leaves, one to five nymphs in a gall."

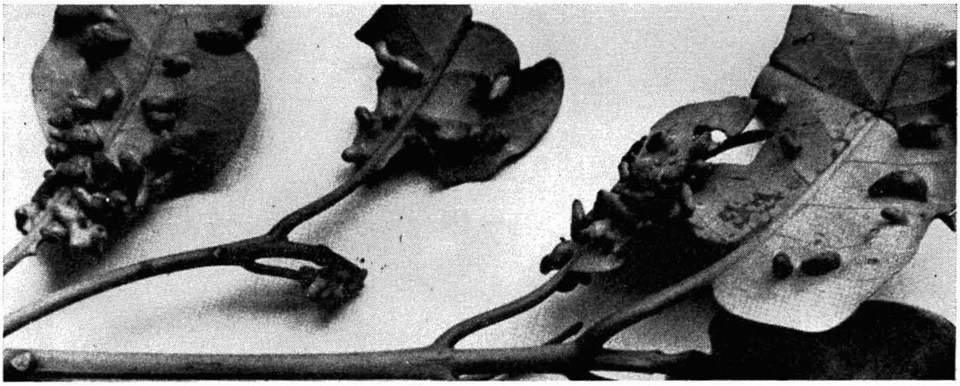


Figure 10—Galls of *Kuwayama pisonia* Caldwell on the leaves of *Pisonia sandwicensis.*

Kuwayama tipicola Caldwell (figs. 5, 6).
Kuwayama tipicola Caldwell, 1940:392, pl. 22, fig. 7; pl. 23, figs. 8, 9, 9a.

Endemic. Oahu (type locality: Niu Ridge).
Hostplant: *Chrysophyllum.*
The types are in the Experiment Station, Hawaiian Sugar Planters' Association.
This is an isolated species readily distinguished by its sharply pointed wings alone. The nymph is described by Caldwell. It forms deep, open-topped, crater-like galls on the leaf petioles or midribs of the hostplant.

Genus **PAUROTRIOZANA** Caldwell, 1940:396

This is a monotypic, endemic genus whose genotype, it appears to me, is essentially a dark-winged *Hevaheva* derivative which has lost the erect, bristly setae of the wing veins and body. The top of the head of the genotype, as seen from directly in front, is unusually deeply V-shaped in transverse dorsal contour, and the eyes appear to be set at the ends of stout, stalk-like lobes.

Paurotriozana adaptata Caldwell (figs. 5, 11).
Paurotriozana adaptata Caldwell, 1940:396, pl. 22, figs. 3, 13, 13a. Genotype.

Endemic. Oahu (type locality: near Kolekole Pass).

Hostplant: *Cryptocarya.*

The holotype is in the Experiment Station, Hawaiian Sugar Planters' Association.

Only a single adult specimen of this interesting and attractive psyllid is known. It was reared from a leaf gall. The nota of the thorax are quite shiny, although finely reticulate, and the wing membrane is shiny and uniformly amber-colored throughout.

The nymph has been described by Caldwell. It forms a gall which raises a callus on both sides of the leaf and which at maturity measures between 1.5 and 3 mm. in diameter. The four galls examined by me were situated near the midrib and placed in pairs so that they coalesced. On the underside of each gall is a subcircular orifice between 0.4 and 0.5 mm. across, through which the adult escapes. One of the galls had a nymph within it, and the back of the nymph was pressed tightly against the opening, thus sealing it. The transverse dividing line of the nymph made it appear that the opening was closed by a pair of doors (fig. 11).

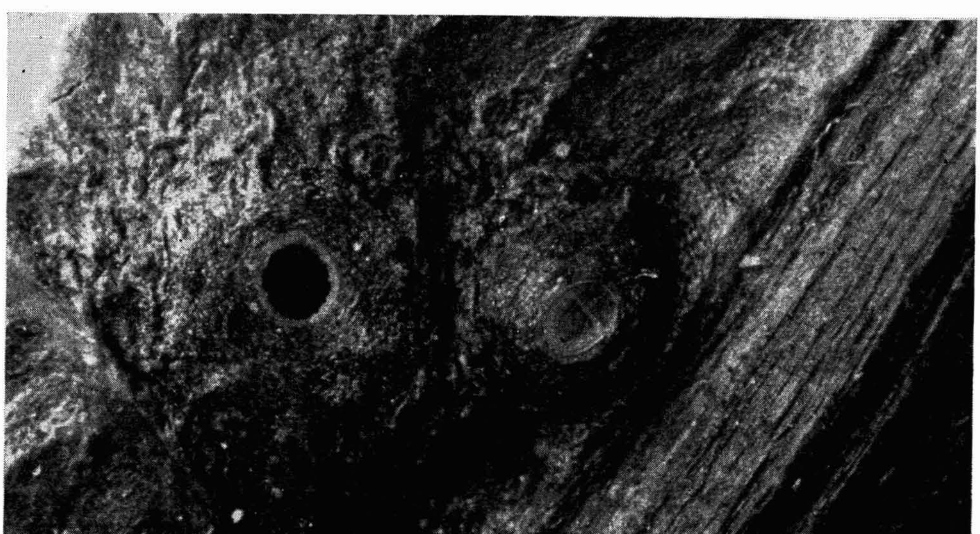


Figure 11—Galls of *Paurotriozana adaptata* Caldwell on lower surface of leaf of *Cryptocarya.* A nymph is in the gall on the right; the adult has emerged from the left gall.

Genus **MEGATRIOZA** Crawford, 1915

This genus was originally erected for a Philippine species, and the bulk of the species assigned to it are Pacific. Some writers have expressed doubt as to the validity of the genus, and Ferris considered it a synonym of *Trioza*. It may be that our described species are local offshoots of *Trioza* and of different origin from the other species assigned to the genus. However, other species occur in Samoa and Fiji.

The principal distinguishing character of the genus in the Hawaiian fauna is the presence of a dentiform process on the subbasal callus of each hind tibia. On certain of our psyllids this callus is better developed than on others and on some it is asperate. There is really not a great deal of difference between a well-callused tibia and the development of a small tooth-like process upon it.

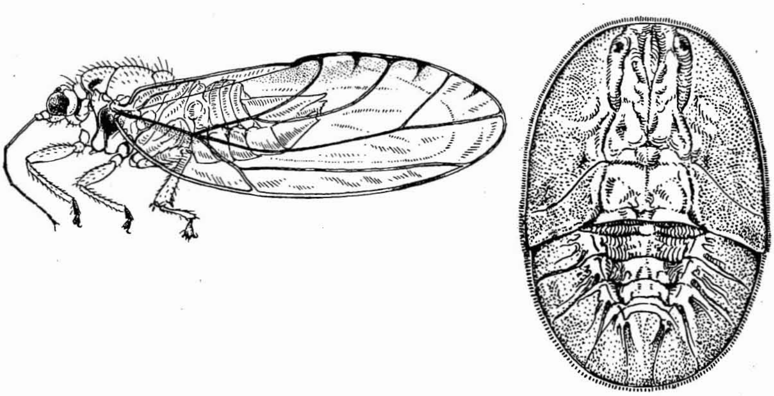


Figure 12—*Megatrioza palmicola* Crawford, adult and nymph. (Abernathy drawings.)

Megatrioza palmicola Crawford (figs. 2, c; 4; 12).
Megatrioza palmicola Crawford, 1918:452, pl. 8, fig. 6.

Endemic. Oahu (type locality: mountains above Punaluu).

Hostplant: *Pritchardia* (native fan palm).

The type is in the Experiment Station, Hawaiian Sugar Planters' Association.

"The insects live on the younger fronds, especially those just unfolding, from which they can readily suck the sap and in the folds of which they find good refuge and seclusion." (Crawford, 1918:453.)

Swezey (*Proc. Hawaiian Ent. Soc.* 4(2):256,1920) notes that "The young live externally on the leaves, not in galls, and produce a large quantity of wooly wax."

This is the largest of our psyllids, for some examples attain an over-all length of 6 mm. In the fore wings, media forks distinctly *basad* of a line drawn between the apices of Rs and Cu_1. The usual dark or infumate markings of the fore wings are as follows: a patch on the anterior side at the forking of the main vein

(R+M+Cu), a band along almost the entire length of 1st A which expands in the cell angle where Cu_2 joins the margin, a darker marginal spot at the apex of 1st A, between Cu_1 and Cu_2, between M_3+_4, and between M_3+_4 and M_1+_2. The hind wings reach, or almost reach, the apex of Rs.

Specimens determined as this species have been examined from *Pritchardia* palms from Hawaii and Kauai, but they are distinct and represent undescribed forms.

Genus **HEVAHEVA** Kirkaldy, 1902:113

Hevaheva is known only from Hawaii. The wing veins have the setae highly developed and together with the erect body setae, which are also longer and more conspicuous than in most of our other genera, give the species a bristly appearance which is outstanding in some forms (but in at least *minuta* from Kauai, these setae are inconspicuous and such species may confuse the worker). The dark apical spines of the posterior tibiae number from five to 10, whereas our other genera usually have only three or four. The genal cones are comparatively short, and they are variable among the species. The dark, hind marginal spots found on the fore wings of *Trioza* and certain other allied genera are absent or obsolete in this group. "This genus is probably endemic here and probably a derivative of *Trioza*. The wing venation is suggestively similar in these two genera here, and in the *Trioza* species the veins and body surface have minute setae which have apparently been highly developed in *Hevaheva*. The marginal granular spots are variable in size in our species of *Trioza* and slight indications of their presence in a few species of *Hevaheva* suggest the possibility of the transition." (Crawford, 1918:448.)

Key to the Species of Hevaheva

1. Fore wings entirely without maculae and not dark but clear and pale, veins pale or comparatively pale, not dark...... 2
   Fore wings either with pale or dark-brown maculae or almost entirely dark colored, or veins dark and membrane comparatively pale-brown infumate.............. 3

2(1). Fore wings with setae unusually inconspicuous for the genus, M forking at a point approximately on a line drawn between apices of Rs and Cu_1 or farther distad (variable), distance between apices of Cu_1 and Cu_2 about equal to that between Cu_1 and M_3+_4; a small (fore wing 1.2–1.75 mm. long), very pallid species from Kauai... ....**minuta** Crawford.
   Fore wings with conspicuous erect setae on veins, M forking distinctly basad of a point on a line drawn between apices of Rs and Cu_1, distance between apices of Cu_1 and Cu_2 much greater than that between Cu_1 and M_3+_4; fore-wing length usually over 2 mm.; forming galls on *Pelea* leaves.........................**perkinsi** Kirkaldy.

3(1). Fore wings palely embrowned, somewhat darker basad, but not maculate and not dark brown, mostly hyaline; Hawaii.............................. **hyalina** Crawford.
Fore wings either maculate or almost entirely dark brown... 4

4(3). Fore wings almost entirely dark brown, but with a distinct pale marginal area just basad of Cu_2.......... ....**silvestris** Kirkaldy.
Fore wings not so colored, with more extensive pale areas and usually conspicuously multi-maculate.............. 5

5(4). Fore wings almost entirely clear and with only rather vague, variable, pale-brown blotches at outer base, along R+M+Cu, along R, base of M, and along Cu_2; M forking unusually far basad and M_{2+3} and M_{3+4} unusually elongate; vertex broad and prominent, mostly pale with apical margins contrasting dark; a large (fore wing, 2.5 mm.), stout, very bristly species from Kauai......... .... **aloha** Caldwell.
Not such species, fore wings with more extensive dark areas or with apical dark areas...................... 6

6(5). Fore wings almost entirely clear but with a pale-brown cloud on Cu_2 from near its origin and expanding to margin, and with a pale-brown apical cloud between apices of Rs and M_2 (sometimes also with a small, dark area at apex of Cu_1 and a dark mark along posterior margin between Cu_2 and base)................**swezeyi** Crawford.
Color pattern of fore wings different and more extensive.... 7

7(6). Fore wing with a continuous, variable, irregular, dark vitta from base to apex down middle of wing which expands inward along Cu_2 to wing margin and outward to apex of Rs; a small species with a fore-wing length of about 1.4 to 1.75 mm.; Kauai.................**maculata** Caldwell.
Fore wing without such a continuous dark area but dark coloring broken up and more irregular................. 8

8(7). Base of fore wing clear, an irregular dark band runs diagonally from outer apex of R across to outer lobe beyond 2nd A, but is paler and more indefinite there, a blotch almost entire length of Cu_2, one at origin of Cu_1, one at about its middle, and suffused along M just before its fork and out along each arm of fork to apex and a dark mark at apex of Rs; thoracic nota mostly or largely pale, but with dark markings; Oahu................. ....**monticola** Kirkaldy.
Base of fore wing almost or entirely dark out to approximately a line drawn across wing between apex of R_2 and fork of Cu, usually a little farther, then with an irregular, variable, zigzag, diagonal band from apex of Cu_2 to apex of Rs, and suffused at apex of Cu_1 and M_{3+4} and M_{1+2}; thoracic nota largely dark; Hawaii.. ....**giffardi** Crawford.

Crawford's key to the five species known in 1918 is misleading and will confuse the worker.

Hevaheva aloha Caldwell (figs. 5, 6).
Hevaheva aloha Caldwell, 1940:394, pl. 22, figs. 6, 10; pl. 23, figs. 6, 6a.

Endemic. Kauai (type locality: Mohihi).
Hostplant: *Xanthoxylum.*
The types are in the Experiment Station, Hawaiian Sugar Planters' Association.
This is our stoutest *Hevaheva,* and it is a distinctive form. The dark maculations at the base of the fore wings are pale and may be rather indistinct. The arms of the fork of M are unusually long, and the shape of the head is unlike that of any of our other described species.

Hevaheva giffardi Crawford (figs. 1, b; 2, d; 4).
Hevaheva giffardi Crawford, 1918:452, pl. 8, figs. 5, 5a–c.

Endemic. Hawaii (type locality: Olaa, 3,000 feet).
Hostplant: *Platydesma campanulata* (leaves).
The type is in the Experiment Station, Hawaiian Sugar Planters' Association.
This species appears to be a close ally of *monticola,* and perhaps it is its representative on Hawaii. It is generally similar to *monticola,* but the color pattern of the wing is distinct, as indicated in the drawings.
In *Proc. Hawaiian Ent. Soc.* 4(2):256, 1920, the following note appears: "Mr. Swezey reported having collected large numbers of this Psyllid on *Platydesma campanulata* at Glenwood, Hawaii. There were no galls present on the leaves, nor could any young stages be found, so that the habits of the young of this species could not be ascertained."

Hevaheva hyalina Crawford (fig. 3, k).
Hevaheva hyalina Crawford, 1918:451.

Endemic. Hawaii (type locality: Glenwood, Olaa, 2,400 feet).
The type is in the Experiment Station, Hawaiian Sugar Planters' Association.
This species is close to *silvestris,* if it is really specifically distinct from that species. *H. silvestris* is a much darker-colored insect than the type of *hyalina,* however. Additional specimens are necessary to reach a decision as to its status.

Hevaheva maculata Caldwell (figs. 5, 6).
Hevaheva maculata Caldwell, 1940:396, pl. 22, fig. 5; pl. 23, figs. 2, 2a.

Endemic. Kauai (type locality: Kauaikinana).
Hostplant: *Pelea.*
The types are in the Experiment Station, Hawaiian Sugar Planters' Association.
This is a small species which has the dark color of the fore wings largely confined to an irregular submedian zone or rough vitta from base to apex.

Hevaheva minuta Crawford (fig. 3, g, h).
Hevaheva minuta Crawford, 1925:28.

Endemic. Kauai (type locality: Nualolo).

Hostplant: *Pelea.*

The types are in the Experiment Station, Hawaiian Sugar Planters' Association.

The nymphs form no galls but live free on the leaves. They produce a pair of long, blue, caudal wax filaments.

This is a tiny, delicate, pallid species which has the setae of the wing veins and nota less highly developed than those of the other members of the genus. In fact, it might be mistaken for a *Kuwayama.*

Hevaheva monticola Kirkaldy (fig. 2, a).
Hevaheva monticola Kirkaldy, 1908:205. Crawford, 1918:451.

Endemic. Oahu (type locality: Mount Tantalus, 2,000 feet).

Hostplant: *Pelea.*

This species was described from a pair collected by Perkins, and only a few specimens appear to have been taken since, although the type locality is the most thoroughly collected place in the Hawaiian Islands. This original pair has been located in the Perkins collection at the Bishop Museum, and I have found that it was not labeled as the type mount by Kirkaldy (as he frequently failed to do with type specimens). I have designated this pair as the types and placed the card containing the two spread individuals in the type collection at the Bishop Museum.

This is one of our prettiest psyllids and has a maculate wing pattern somewhat like that of *giffardi.* Crawford's statement in his key (1918:449) that the wings are "nearly all brown or black" is erroneous.

Hevaheva perkinsi Kirkaldy (figs. 3, c; 4; 13; 14).
Hevaheva perkinsi Kirkaldy, 1902:113, pl. 4, fig. 1. Crawford, 1918:449, pl. 8, figs. 4, 4a–c; 1925:27. Genotype.

Endemic. Oahu (type locality: Konahuanui Ridge ?), Kauai (?), Hawaii (?).

Hostplants: *Pelea clusiaefolia, Pelea lydgatei, Pelea wawraeana* (?).

The holotype is presumably in the British Museum.

There appears to be some confusion concerning this species, because some records note that the nymphs form galls on *Pelea* leaves and others state that the nymphs live free upon the leaves or are fixed upon the leaves. I have questioned the locality records of Kauai and Hawaii as applied to this species, and I feel that a careful study of assembled material coupled with more detailed life history observations will reveal that more than one species is involved here. On Oahu,

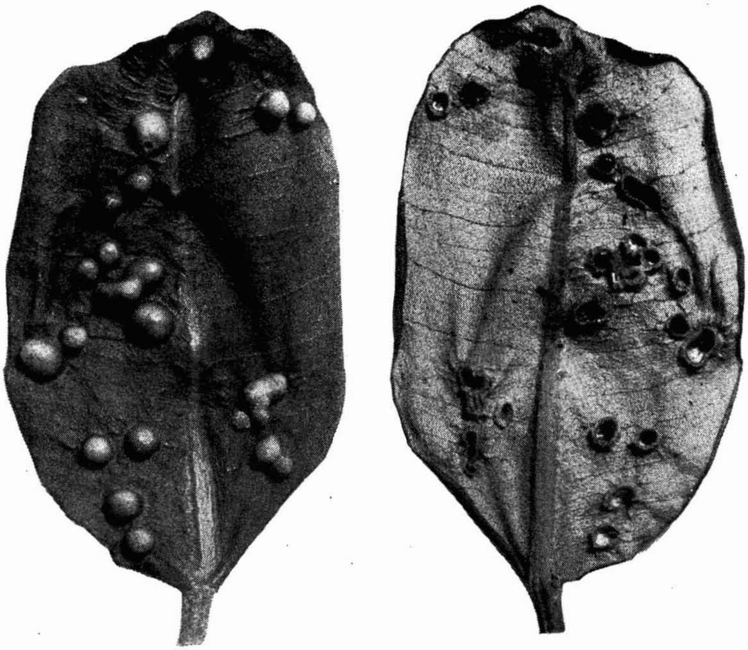


Figure 13—Galls of *Hevaheva perkinsi* Kirkaldy on leaf of *Pelea* species from Palolo, Oahu; left, dorsal surface; right, ventral surface.

Figure 14—Galls of *Hevaheva perkinsi* Kirkaldy on leaf of *Pelea clusiaefolia* (dorsal surface), Waikane, Oahu. Compare the shape of the galls with those of the foregoing figure. Is the difference caused by a different reaction in the two species of *Pelea*, or are two kinds of *Hevaheva* involved?

at least, the non-gall-forming species is orange-colored when alive, whereas the species I consider to be *perkinsi* is an apple-green-colored, gall-forming species. There may be a complex involved here; I have noticed differences in the shape of the galls on different species of *Pelea*.

Hevaheva silvestris Kirkaldy (fig. 3, j).
Hevaheva silvestris Kirkaldy, 1908:206.

Endemic. Kauai (?), Oahu (type locality: Mount Tantalus, 2,000 feet).
Hostplant: *Pelea rotundifolia.*
The unique specimen from which this species was described was located in the Perkins collection at the Bishop Museum. Kirkaldy, as he often neglected to do, failed to put a holotype label on it. I have appropriately labeled it as the holotype and have placed the specimen in the type collection at the Bishop Museum.
This is our darkest-colored *Hevaheva,* and the fore wings are almost entirely dark brown. The Kauai specimens are possibly a subspecies or species and need further study. The nymphs live free on the host leaves.

Hevaheva swezeyi Crawford (fig. 2, b).
Hevaheva swezeyi Crawford, 1928:33.

Endemic. Maui (type locality: Olinda).
Hostplant: *Pelea.*
The type series of this species is in the Experiment Station, Hawaiian Sugar Planters' Association. One example bears the label "*Hevaheva swezeyi* n.sp. (Crawf.)," but none is labeled as the type. It appears that Crawford neglected to label a type specimen. Crawford occasionally had the bad habit of putting a small label reading "Type" on a specimen without giving the name of the species. He also failed to designate any paratypes from the series of examples of the various Hawaiian species described by him.
"The nymphs adhere closely to the *Pelea* leaves, resembling small Coccidae superficially. They do not form galls." (Crawford, 1928:33.)

Genus **CRAWFORDA** Caldwell, 1940:397

This is a local, monotypic *Trioza* derivative which has the radius longitudinally fused with the wing margin and appearing to extend to the apex of Rs as a thickened margin, thus forming a narrow "pterostigma" as is indicated in the figure. I do not consider it a strong genus.

Crawforda triopsyllina Caldwell (figs. 5, 6).
Crawforda triopsyllina Caldwell, 1940:397, pl. 22, figs. 9, 12, 12a; pl. 23, figs. 4, 4a. Genotype.

Endemic. Molokai (type locality: Kainalu, 1,600 feet).
Hostplant: *Tetraplasandra.*
The types are in the Experiment Station, Hawaiian Sugar Planters' Association.
The nymphal form has been described by Caldwell. Evidently the nymphs live free on the leaves.

Genus **SWEZEYANA** Caldwell, 1940:389

This is a native group allied to *Trioza,* but which readily can be separated by the very long genal cones and by the fact that the radius of the fore wings does not extend distinctly beyond the origin of Rs but becomes obsolete at that point. The radius in the fore wings normally extends uninterruptedly directly to the wing margin. These characters are fully illustrated by the drawings (figs. 5, 15, A).

One of the known species occurs on Maui and the other on Kauai. Both are attached to *Sideroxylon.* It is to be anticipated that other species will be found on other islands on the same host. The species are distinctive.

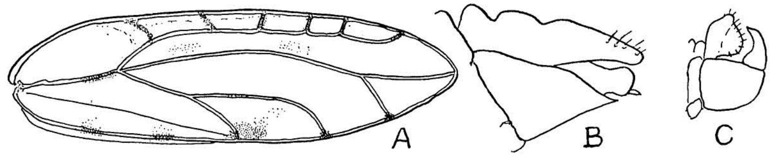


Figure 15—*Swezeyana reticulata* Caldwell. **A,** fore wing; **B,** female terminalia; **C,** male terminalia. (After Caldwell, 1940.)

Key to the Species of Swezeyana

1. Fore wing with several dark cross-veins or pseudo-cross-veins between Rs and wing margin; fore wings 2.4–3.0 mm. in length, slightly infumated, with darker patches at apices of Cu_2, Cu_1, M_{3+4}, the one at the apex of Cu_2 most conspicuous .... **reticulata** Caldwell.
2. Fore wings 3.0–4.5 mm. long, without such cross-veins and without such dark maculae, membrane milky hyaline and usually iridescent, the obsolete radius usually appearing to run distad for some distance between Rs and costal margin .... **elongagena** Caldwell.

Swezeyana elongagena Caldwell (figs. 5, 6).

Swezeyana elongagena Caldwell, 1940:390, pl. 22, figs. 1, 11, 11a; pl. 23, figs. 1, 7. Genotype.

Endemic. Kauai (one example ?), Maui (type locality: Haelaau).

Hostplant: *Sideroxylon.*

The types are in the Experiment Station, Hawaiian Sugar Planters' Association.

The nymphs, which do not form galls, are described by Caldwell.

The Kauai record may be in error.

Swezeyana reticulata Caldwell (fig. 15, A–C).

Swezeyana reticulata Caldwell, 1940:390, fig. 1.

Endemic. Kauai (type locality: Kalalau Trail).
Hostplant: *Sideroxylon.*
The types are in the Experiment Station, Hawaiian Sugar Planters' Association.
The wings of this form appear spotted.

Genus **CEROTRIOZA** Crawford, 1918:454

Crawford, 1920:374, redescription.

This is an endemic genus which Crawford considered to be a derivative of the widespread *Leuronota* Crawford. The structure of the vertex is unique among the Hawaiian psyllids, because each side is produced forward to form a horn-like projection which protrudes beyond the fore edges of the bases of the antennae, and the projections resemble misplaced genal cones, with which structures they are apt to be confused. The genal cones, however, are absent in this genus. I feel that the status of the genus needs further elucidation.

Key to the Species of Cerotrioza

1. Fore wings with an irregular, variable, longitudinal dark cloud composed of dots and anastomosed dots of brown color.................................. **bivittata** Crawford.
2. Fore wings with an irregular pattern of brown which is not essentially axial as it is in *bivittata*......... **bridwelli** Crawford.

Cerotrioza bivittata Crawford (figs. 1, c; 2, f; 4)..
Cerotrioza bivittata Crawford, 1918:454, pl. 8, figs. 7, 7a.

Endemic. Oahu (type locality: Opaeula), Maui, Hawaii.
Hostplant: *Xylosma hawaiiense.*
The holotype, which lacks the left fore wing, is in the Experiment Station, Hawaiian Sugar Planters' Association.
Swezey found that the nymphs live free on the leaves of the hostplant in slight depressions surrounded by a red area, and that they do not form galls.
The typically speckled fore wings form a characteristic and conspicuous recognition character.

Cerotrioza bridwelli Crawford.
Cerotrioza bridwelli Crawford, 1920:375, fig. 1.

Endemic. Oahu (type locality: mountains above Punaluu).
This species was described from a single example. I have been unable to locate the type, and to my knowledge no specimens have been collected since the type was found.

Subfamily PAUROPSYLLINAE

The only record of this subfamily in Hawaii is based upon a single specimen captured on Molokai. The group, as represented here, can easily be separated from all our other psyllids because of its wing venation. Figure 3, d, shows the distinctive features. There are, however, other distinguishing characters, which have been listed by Crawford and other workers, such as the shape of the head, which is rounded forward and downward, and the exposed frons.

Genus **PAUROCEPHALA** Crawford, 1914

The genotype of this genus is a Philippine species (*P. psylloptera* Crawford).

Paurocephala, species not determined (fig. 3, d).
Paurocephala sp., Crawford, 1927:424.

A single example of this species was collected from pokeweed at Kamiloloa, Molokai, by Bryan, December 20, 1925, elevation 3,200 feet, and is now in the Bishop Museum. Unfortunately, the specimen is badly mounted and is considerably damaged; hence it was not described by Crawford. No other specimens have come to hand, and this interesting addition to our local psyllid fauna must remain undescribed. It may be a native insect, and it is conspicuously different from our other psyllids.

Superfamily ALEYRODOIDEA (Handlirsch, 1903)

Aleurodoidea Handlirsch, 1903.
Aleurodides Handlirsch, 1925, suborder.
Aleurodoptera Pierce, 1936, order.

This division holds only the type family.

Family **ALEYRODIDAE** Westwood, 1840

Aleurodidae of authors.

Aleyrodids, White Flies

The small family Aleyrodidae is composed of tiny insects which obtained the common name "white flies" from the fact that the wings and bodies of the adults are covered with a fine, powdery or flour-like, white wax. Thus, the adults resemble somewhat the neuropteroid Coniopterygidae with which they might be confused. Linnaeus and other workers thought that they were minute moths. The nymphs are similar superficially to those of the psyllids and also are easily confused with coccids. The adults have two ocelli situated near the inner, upper, fore edges of the eyes; compound eyes which may be reniform or divided; seven-segmented antennae (the first two segments are short); two-segmented tarsi, with an empodium (paronychium) between the claws. The four wings are comparatively short and broad, broadly rounded apically, often with serrulate and setose margins, and have the venation greatly reduced with at most only veins R, Rs, M, Cu and A present, usually more reduced, and many species have only one vein (Rs) present; both pairs of wings are well developed in the two sexes and are held nearly flat over the afterbody and extended laterally.

The eggs of most species are attached, almost invariably to the undersides of leaves, by means of short or elongate stalks. Their surfaces may be smooth or characteristically sculptured. Many species lay their eggs in one or more semicircular or circular concentric rows, but others scatter their eggs over the surface of the leaf.

The first-stage nymphs are glistening, pale, somewhat translucent creatures with well-developed antennae and functional legs. After emerging from the eggs they crawl only a short distance before selecting a site for permanent attachment.

There are three larval instars followed by a pupal instar. The legs degenerate after the first molt and the nymphs then closely resemble the soft scales. The pupal instar differs slightly or conspicuously from the previous larval instars, and it is thicker and usually more ornamented with wax filaments and processes

than the other instars. During the early part of the pupal instar the insect feeds in the normal way, but feeding later stops and the processes connected with metamorphosis to adulthood take place. This fourth stage is more or less intermediate between the usual nymph-to-adult series and the larva-pupa-adult series found in the higher insect orders, but it is considered to be, and is referred to as, the pupa by authors.

The adults of many species are much like one another, and this fact, coupled with the easier collection and preservation of pre-adult stages, has resulted in the use of the pupae for identification and general taxonomic work. The pupae usually provide better differential characters than other stages; in fact, in some groups it appears impossible to separate the species except by the differences exhibited by the pupae.

One of the most characteristic features of the group is the structure known as the vasiform orifice which is well developed on the larvae and pupae but degenerates somewhat in the adults, in which forms it is not generally considered to be of taxonomic use. The vasiform orifice is situated on the dorsal surface of the last abdominal segment and

> is an opening variously modified in shape, with a lid, the operculum, which is hinged to the cephalic margin; this ranges in size from minute to large; lying within the orifice beneath the operculum is the lingula, a strap-shaped organ, also attached to the cephalic margin; in general shape, cylindrical at base and more or less enlarged at the distal end; in some specimens it is entirely obscured by the operculum, while in others it is conspicuously long, even projecting beyond the orifice; the distal portion is frequently protruded and dorsally recurved. The operculum and the distal part of the lingula are usually setose, and the latter, as a rule, bears two long apical hairs. (Bemis, 1904:478.)

For a detailed discussion of morphology, anatomy, classification, etc., see Quaintance and Baker, especially the 1913 report, and Sampson, 1943, for an up-to-date review. The only paper dealing with the Hawaiian species as a whole is that of Kotinsky, 1907.

The species established in Hawaii evidently breed continuously throughout the year but are more abundant in certain seasons than in others. The females mate and begin oviposition a few hours after emergence from the pupae. Some species are known to be parthenogenetic, and only males are said to be produced from unfertilized eggs in other species. Schrader (1926:189–196) reported two parthenogenetic races in *Trialeurodes vaporariorum,* one of which produced males, the other females, whereas fertilized females gave mixed male and female offspring.

In those species which lay their eggs in a circle or semicircle, the female inserts her rostrum into the leaf and pivots on it as she deposits her eggs in the characteristic row or concentric rows. The eggs and the leaf surface within the arc of eggs may be distinctly dusted with the white, powdery wax of the mother. The females of some species are known to lay as many as 250 eggs.

Copious amounts of honeydew are produced and excreted through the anus, which opens within the vasiform orifice, and the honeydew accumulates on the lingula and is thence cast off.

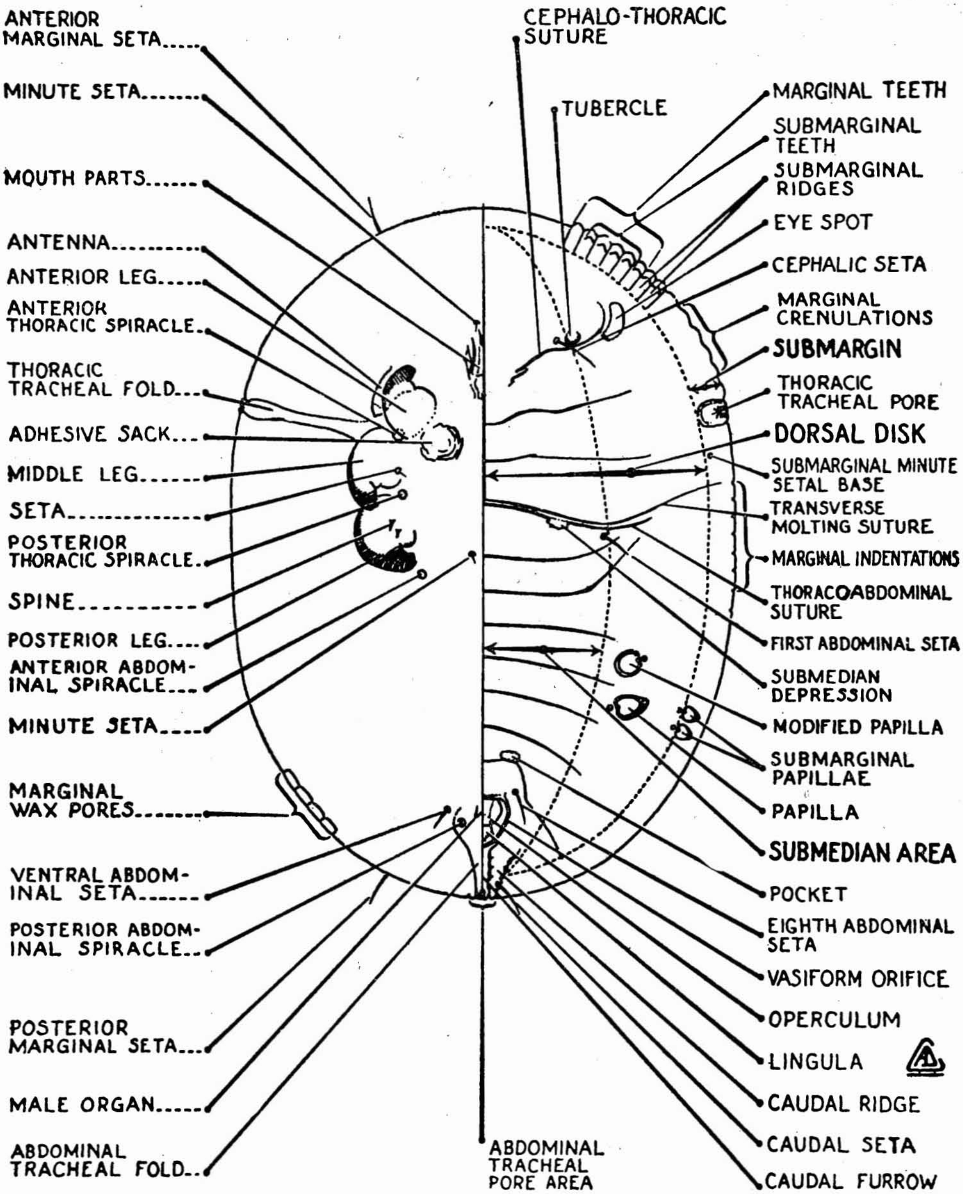


Figure 16—Diagram of an aleyrodid pupa (ventral aspect, left; dorsal aspect, right) with various parts labeled. (After Russell, 1948.)

A number of species of this family are of real economic importance—two of the most well-known detrimental species are the greenhouse and the citrus white flies. The damage done to the hostplants is of two principal types: one is the extraction of the plant juices and the other results from the growth of masses of sooty mold

on the honeydew produced by some species. The honeydew may dry to a brown crust on the plant leaves, cause them to appear burned, and interfere with normal leaf functions even though the sooty mold does not develop. Also, the feeding is definitely toxic to some plants whose leaves become crinkled and distorted when heavily attacked. Some species are vectors of plant diseases.

Aleyrodids have numerous enemies, including many minute hymenopterous parasites. The normal opening made by an adult emerging from a pupal case is an inverted T-shaped dorsal aperture, but when a parasitic wasp issues, it creates a ragged hole in the pupal case; it is thus easy to ascertain the presence of parasites. Coccinellid beetles, some Heteroptera, green and brown lacewings, predaceous thrips and mites are known to prey upon the nymphs or eggs, and certain fungi have been reported to attack some species.

In addition to the four species listed below, an unidentified species has been reported from coffee.

Miss Louise Russell has given me some much-appreciated advice regarding this family.

Subfamily ALEYRODINAE Enderlein, 1909

This subfamily was characterized by Quaintance and Baker (1913:84) as follows: ". . . the media of the forewing is lost, but the cubitus is retained as a distinct vein in most genera. The radial sector forms the main vein of the wing, and radius$_1$ may or may not be present. No compound pores are present in the pupa case and the paronychium is broad and hairy."

All the Hawaiian forms belong to this subfamily, and the other two subfamilies of the group, the Udamoselinae and Aleurodicinae, are unrepresented here.

Key to the Genera of Aleyrodinae Found in Hawaii

1. Pupal case appearing thick, elevated slightly or conspicuously above surface of host leaf by a palisade of white wax which forms vertical sides of case, and with many conspicuous, long, lateral and/or dorsal glass-like, setiform, wax filaments (with a submarginal row of papillae and pores) .... **Trialeurodes** (Cockerell).

   Pupal case not so elevated above leaf surface and without such numerous dorsal and lateral wax filaments, at most with a few erect filaments (without a submarginal row of papillae and pores) 2

2(1). Pupal case elongate, elliptic in outline (vasiform orifice elongate, narrow triangular, lingula long, projecting by at least one-half its length behind the short operculum, with a distinct furrow extending from behind orifice to caudal margin of body) ..... **Bemisia** Quaintance and Baker.

   Pupal case broadly ovate or subcircular 3

3(2). Pupal case with thoracic tracheal folds distinct and with numerous minute spines; vasiform orifice small, oper-

culum largely covering lingula and nearly filling orifice .... **Dialeurodes** (Cockerell).

Pupal case with or without distinct thoracic tracheal folds but without minute spines; vasiform orifice large, operculum short, filling only about one-half of orifice........ 4

4(3). Vasiform orifice in a subpyriform, transversely ridged pit or depression, continuous with caudal furrow, operculum covering entire lingula; thoracic tracheal pores present .... **Pealius** Quaintance and Baker.

Vasiform orifice not situated in a pit or depression, cordate, not continuous with caudal furrow, operculum not covering lingula; thoracic tracheal pores absent......... .... **Aleyrodes** Latreille.

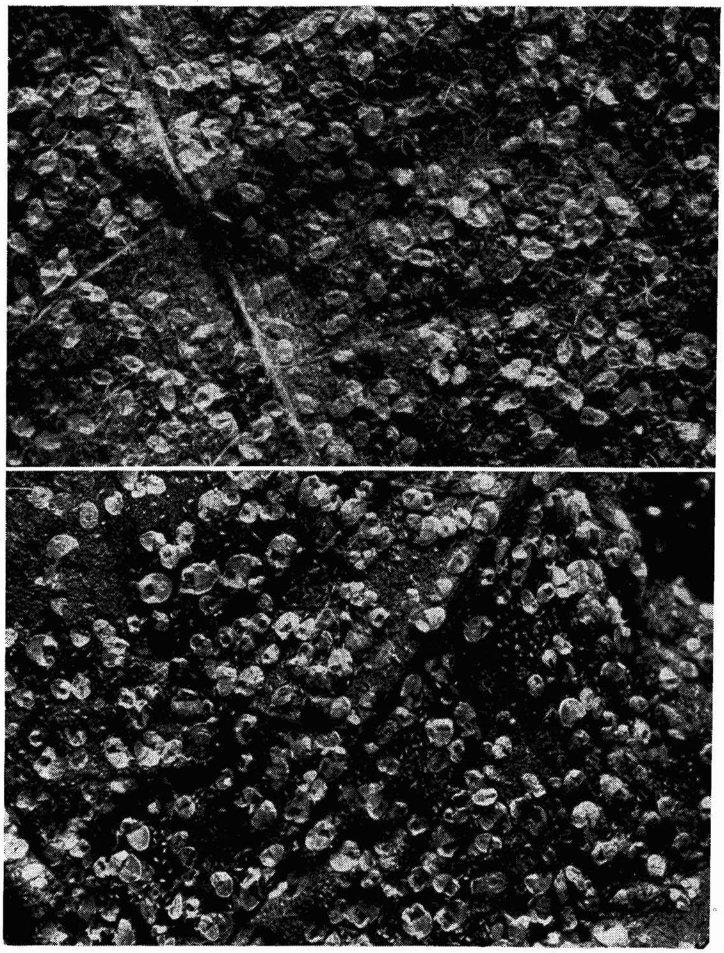


Figure 17—Some white flies. Upper figure, *Pealius hibisci* (Kotinsky), pupal cases on leaf of *Hibiscus tiliaceus*. Lower figure, *Dialeurodes kirkaldyi* (Kotinsky), pupal cases on leaf of *Morinda citrifolia*.

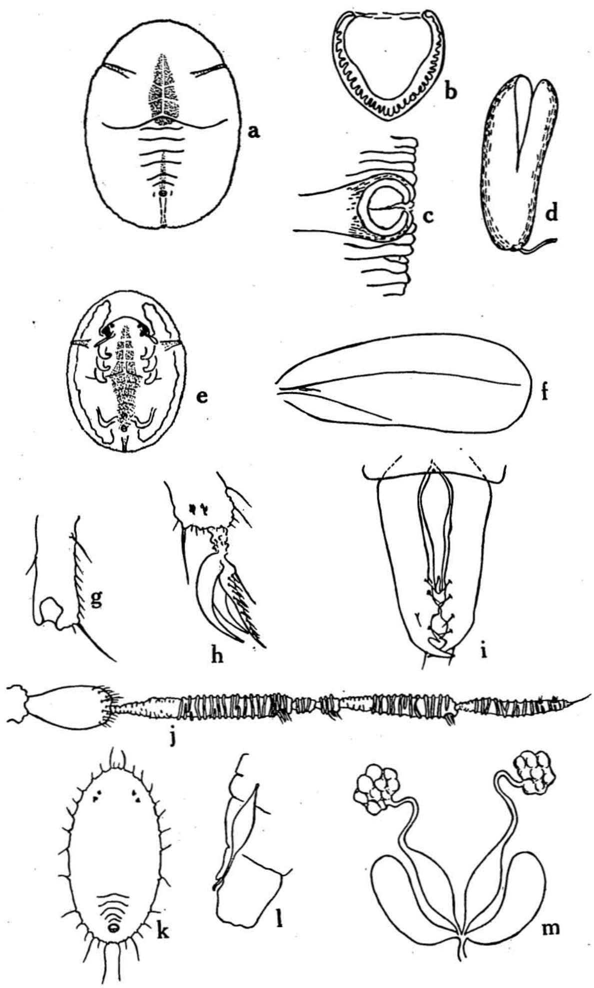


Figure 18—*Dialeurodes kirkaldyi* (Kotinsky). **a**, pupa; **b**, vasiform orifice; **c**, thoracic tracheal pore; **d**, egg; **e**, pupa with developing adult showing through; **f**, fore wing; **g**, apex of tarsus of adult; **h**, claw of adult; **i**, male genitalia; **j**, antenna; **k**, first instar nymph; **l**, vasiform orifice of male showing rectum; **m**, internal reproductive organs of male. (Redrawn from Quaintance and Baker, 1917.)

Genus **DIALEURODES** (Cockerell) Quaintance and Baker, 1914:97

Aleurodes subgenus *Dialeurodes* Cockerell, 1902.

Pupa case variable in size, elliptic to subcircular in outline; color usually yellowish, varying in some species to brownish; margin of case toothed, the wax tubes irregular in outline and but little developed; submarginal area not separated from dorsal disk; dorsum without papillae or pores; tracheal folds evident, in some species very conspicuous, terminating on margin of case in a pore, the folds often showing dotlike, linear, or polygonal markings; wax secretion

absent or very scant. Vasiform orifice relatively small, transversely oval or subcircular, with or without comb of teeth on inner lateral and caudal margins; operculum large, mostly filling the orifice and obscuring the lingula.

Adult with one flexure in radial sector of forewing and no trace of media. Antennae of seven segments, segment VII not distinctly shorter than segments IV, V, and VI, but usually longer than these. Sexes about equal in size, the claspers of male with a few prominent spines. (Quaintance and Baker, 1914:97.)

Dialeurodes kirkaldyi (Kotinsky) (figs. 17; 18, a–m; 19).

Aleyrodes kirkaldyi Kotinsky, 1907:95, pl. 1, fig. 2, a–d.

Dialeurodes kirkaldyi (Kotinsky) Quaintance and Baker, 1914:98; 1917:416, pl. 67, figs. 1–13; pl. 64, fig. 2; redescription.

Kirkaldy's white fly.

Kauai, Oahu (type locality: Honolulu), Molokai.

Immigrant. Also known from British Guiana.

Type material in Territorial Board of Agriculture and Forestry collection, Honolulu.

Hostplants: *Beaumontia grandiflora, Jasminum sambac, Morinda citrifolia,* star jasmine (*Jasminum multiflorum*).

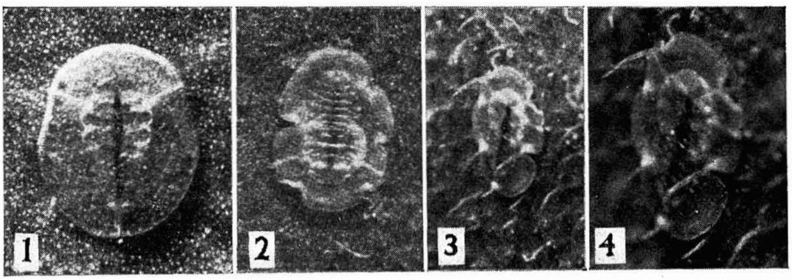


Figure 19—*Dialeurodes kirkaldyi* (Kotinsky). 1, pupa of normal form on a smooth-leaved jasmine; 2–4, pupae with deformed margins growing among the hairs of a hairy-leaved jasmine. (After Swezey, *Proc. Hawaiian Ent. Soc.* 11(3):269, 1943.)

Parasite: minute hymenopterous parasites, presumably the same as one or more of those attacking other white flies here, have been observed, but their identity is unknown to me.

This species may be distinguished from the other aleyrodids found in the Hawaiian Islands by its lack of the bristling wax filaments and submarginal papillae and pores of *Trialeurodes* and its broad, subcircular pupal case on which the tracheal folds of the thorax can be distinguished as distinct lines which run obliquely forward to the anterior side margins. The pupal cases are usually larger than are those of our *Pealius*.

As pointed out by Swezey (*Proc. Hawaiian Ent. Soc.* 11(3):269, 1943), the normal nymphal and pupal shape is assumed on smooth leaves, but when the insects occur on stiff-haired leaves the sides of the body become indented where they grow against unyielding hairs (see fig. 19).

Heavy infestations on *Morinda citrifolia* ("noni") cause a crinkling of the leaves and dulling or browning of their color so that the plants have a generally unhealthy appearance.

The eggs, which have short stalks and no conspicuous surface sculpturing, are scattered over the hostplant leaves.

According to Miss Russell, Kotinsky's description (1907:96) is largely erroneous.

Genus **PEALIUS** Quaintance and Baker, 1914:99

Pupa case medium in size, elliptic in outline; color variable; margin of case toothed, the wax tubes well developed; submarginal area not separated from dorsal disk; dorsum without papillae or pores; thoracic tracheal folds not discernible, though there is a distinct furrow from vasiform orifice to caudal end of case. Vasiform orifice situated in a pit, which is more or less pyriform in outline and transversely ridged, the outline of the orifice being subrectangular; operculum subrectangular, short, filling about half the orifice; lingula short, the distal extremity visible caudad of operculum, flattened and knobbed. (Quaintance and Baker, 1914:99.)

Pealius hibisci (Kotinsky) (figs. 17; 20, d–f).

Aleyrodes hibisci Kotinsky, 1907:96, pl. 1, fig. 3, a–d.

Pealius hibisci (Kotinsky) Quaintance and Baker, 1914:99.

The hibiscus white fly.

Oahu (type locality: Honolulu ?), Molokai, Hawaii.

Immigrant. Source unknown.

Type in the collection of the Territorial Board of Agriculture and Forestry, Honolulu.

Hostplants: *Hibiscus tiliaceus* ("hau"), cultivated *Hibiscus* (*rosa-sinensis*), *Hibiscus arnottianus*.

Parasites: *Eretmocerus corni* Haldeman, *Prospaltella transvena* Timberlake, *Encarsia versicolor* Girault, *Encarsia* sp.? (Hymenoptera: Aphelinidae).

This species sometimes becomes extremely abundant, especially in summer and fall, when clouds of the adults may arise from infested *Hibiscus* plants when disturbed. It becomes scarce in the cooler months. A single "hau" tree may have a population of several hundred thousand individuals. The adults may settle by hundreds on all kinds of plants near the hostplant and may be erroneously thought to be feeding on other than the true host.

The eggs are stalked, evidently finely sculptured and are scattered on the lower leaf surfaces.

Genus **BEMISIA** Quaintance and Baker, 1914:99

Pupa case varying much in size, elliptic or oval in outline, broadest across the thorax; color usually pale yellowish; margin toothed, the wax tubes irregular in size and shape; submarginal area not separated from dorsal disk; dorsum without papillae or pores; thoracic tracheal folds sometimes faintly visible. There is a distinct furrow present, extending from the vasiform orifice to the caudal extremity of the case. Vasiform orifice triangular, long and narrow; lingula long and less than half covered at the cephalic extremity by the short operculum.

Adult with one flexure in radial sector of forewing and no spur of media. Antennae of seven segments, of which the third is the longest, the remaining distal ones being subequal. (Quaintance and Baker, 1914:99.)

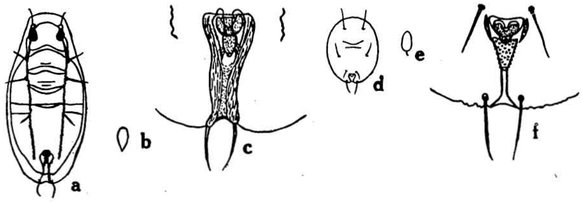


Figure 20—Details of aleyrodids: **a–c**, *Bemisia giffardi* (Kotinsky), **a**, pupa, **b**, egg, **c**, vasiform orifice and caudal margin of pupa; **d–f**, *Pealius hibisci* (Kotinsky), **d**, pupa, **e**, egg, **f**, vasiform orifice and caudal margin of pupa. (Redrawn from Kotinsky, 1907.)

Bemisia giffardi (Kotinsky) (fig. 20, a–c).

Aleyrodes giffardi Kotinsky, 1907:94, pl. 1, fig. 1, a–d.

Bemisia giffardi (Kotinsky) Quaintance and Baker, 1914:100.

Giffard's white fly.

Oahu (type locality: Honolulu), Molokai.

Immigrant. Also recorded from Japan.

Type in the Territorial Board of Agriculture and Forestry collection in Honolulu.

Hostplants: citrus trees, *Clausena lansium*, pomelo.

The elongate pupa case of this species alone will separate it from all our other white flies.

Kotinsky was in error in stating that the eggs have no pedicels. The stalk is short and asymmetrically placed on the egg. The eggs are scattered on the leaf surface.

"Becomes very abundant and the copious honeydew mixed with sooty fungus blackens the leaves giving them a hideous appearance." (Kotinsky, 1907:95.) It has been reported as a serious pest of citrus trees in Japan. It is rarely seen in Hawaii now, but occasional infestations are found.

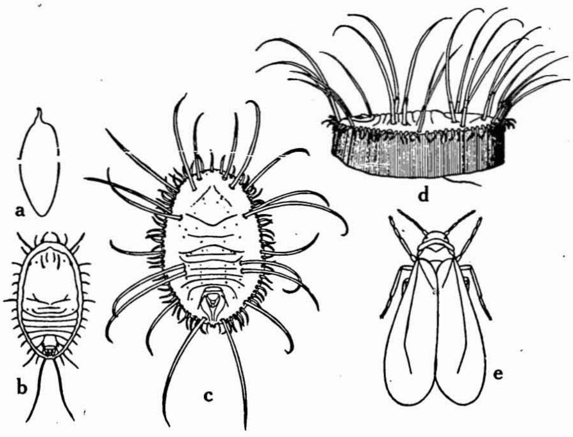


Figure 21—*Trialeurodes vaporariorum* (Westwood). **a**, egg; **b**, young nymph; **c**, dorsal view of pupa; **d**, lateral view of pupa; **e**, adult. The long dorsal wax rods vary in development and may be broken off. (Redrawn from Morrill, 1905.)

Genus **TRIALEURODES** (Cockerell) Quaintance and Baker, 1915:xi

Aleyrodes subgenus *Trialeurodes* Cockerell, 1902.
Asterochiton, in the sense of Quaintance and Baker, 1914:104.

Pupa case medium to small in size, elliptic, usually elevated from the leaf by a palisade of white wax; color variable, ranging from whitish to dark brown; margin of case toothed, the wax tubes moderately developed; submarginal area not separated from dorsal disk; submarginal area with a row of, or a number of, large papillae or pores; thoracic tracheal folds rarely distinguishable; usually a distinct furrow from vasiform orifice to caudal margin of case; wax secretion a series of brittle, glassy rods from dorsal papillae or pores and a palisade of white wax elevating case from leaf; vasiform orifice subcordate, usually notched on caudal end; operculum transversely elliptic, about half filling the orifice; lingula spatulate, the distal extremity exposed caudad of operculum, lobed, and usually armed with two prominent spines.

Adult usually with one flexure in radial sector of forewing and no trace of media excepting in freshly emerged specimens. Antennae of seven segments, segment III the longest, IV to VI subequal; segments imbricated. Sexes nearly equal in size. (Quaintance and Baker, 1914:104.)

Miss Russell's revision (1948) of this genus for North America has come to hand on the eve of going to press and too late to be considered here. Her paper should be consulted for a revised account of the genus.

Trialeurodes vaporariorum (Westwood) (figs. 21, a–e; 22).
Aleyrodes vaporariorum Westwood, Gardener's Chronicle, p. 852, 1856 (not seen).
Asterochiton vaporariorum (Westwood) Quaintance and Baker, 1914:105.

Trialeurodes vaporariorum (Westwood) Quaintance and Baker, 1915:xi.
Aleurodes sonchi Kotinsky, 1907:97, pl. 1, figs. 4, a–d.
Asterochiton sonchi (Kotinsky) Quaintance and Baker, 1914:105.
Trialeurodes sonchi (Kotinsky) Quaintance and Baker, 1915:xi.

The greenhouse white fly.

Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.

Immigrant. Widely distributed. The first published record of the occurrence of this species in the Hawaiian Islands which I have in my file is that by Kotinsky in 1907 (p. 94), but I believe that it was collected by Koebele and others before 1900.

Hostplants: *Emilia*, garden bean, *Lantana*, *Nicotiana glauca*, *Sonchus oleraceus*, strawberry.

Parasites: *Encarsia formosa* Gahan, *Encarsia versicolor* Girault (Hymenoptera: Aphelinidae) in the nymphs and pupae.

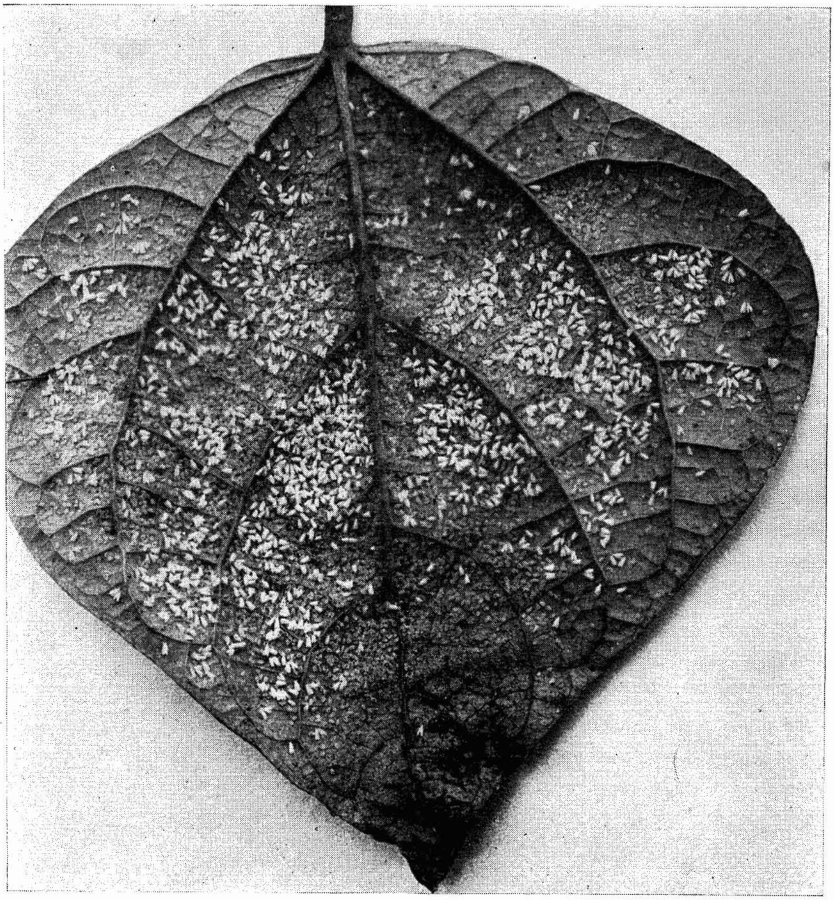


Figure 22—*Trialeurodes vaporariorum* (Westwood), the greenhouse white fly, on a garden bean leaflet. (After Holdaway, *Proc. Hawaiian Ent. Soc.* 11(3):266, 1943.)

The eggs are shortly stalked and are often laid in a semicircle. Sometimes two or more females may choose the same spot for oviposition; the eggs may form a complete circle and be composed of newly laid yellow eggs, dark maturing eggs and empty eggshells.

Kershaw (1913:186) notes that this species has no food reservoir.

The oesophagus is very long and slender, and the posterior portion of it, together with the anterior part of the hind intestine are twisted around each other for some distance, and apparently enclosed with peritrophic membrane. The malpighian tubes are two in number and very large; they appear to be always more or less clear or hyaline and colorless. Besides uric acid there appeared to be hippuric acid crystals in the tubes. The junction of the midgut and hind intestine (where the malpighian tubes originate) is right up at the anterior end of the abdomen, near the base of the oesophagus, when the gut lies in its natural position in the abdomen. The tegmina and wings of this insect are white from the wax excreted from the numberless tiny glands thereon.

This widespread pest has in recent years caused considerable damage to local bean crops, especially in the dry lowland Waianae section of Oahu. In the spring and summer it sometimes builds up such large populations that, reportedly, hardly a square centimeter of the undersides of bean leaves can be found free of the insects, and that severe crop losses result from the attacks. The copious amount of honeydew forms, on the leaves, a crust which dries to a brown color and makes the leaves appear scorched.

Good control has been obtained by the use of a dust containing 1 percent thiocyanate lethane 440 and 0.10 percent pyrethrins (Holdaway, *Proc. Hawaiian Ent. Soc.* 11(3):267, 1943).

For a discussion of the anatomy, histology and development of this species, see L. R. Cary, 1903:125. Mittler (1946:532) has published an interesting account of the production of female offspring from virgin females under the influence of high temperatures.

Genus **ALEYRODES** Latreille, 1796

Aleurodes Burmeister, 1835.

Pupa case small to medium in size, elliptic in outline; color usually yellowish or brownish; margin of case toothed, the wax tubes irregular in outline and rather poorly developed; submarginal area not separated from dorsal disk. There are no well developed papillae or pores as in *Asterochiton,* though minute pores may be present in some species. Tracheal folds not discernible; wax secretion usually absent. Vasiform orifice subcordate, the operculum about half filling the orifice; lingula included within the orifice, but visible caudad of the operculum; the distal extremity setose and armed with a pair of spines.

Adult with two flexures in radial sector of forewing, and media with a very short spur; forewings usually with faint patches of dusky coloration on flexures of radial sector. Antennae of seven segments, of which the third is the longest, the distal ones being subequal; segments imbricated. Sexes nearly equal in size; claspers of male with a few spines. (Quaintance and Baker, 1914:100.)

Key to the Species Found in Hawaii

1. Fore wing with only one vague dark patch at apex of main vein; operculum filling slightly less than one-half of vasiform orifice; submarginal minute setae distad of majority of submarginal pores; on *Oxalis*........**shizuokensis** Kuwana.
2. Fore wing with a dark patch at about middle and a larger one at apex of main vein; operculum filling slightly more than one-half of vasiform orifice; submarginal minute setae mesad of most submarginal pores; on *Iris*...**spiraeoides** Quaintance.

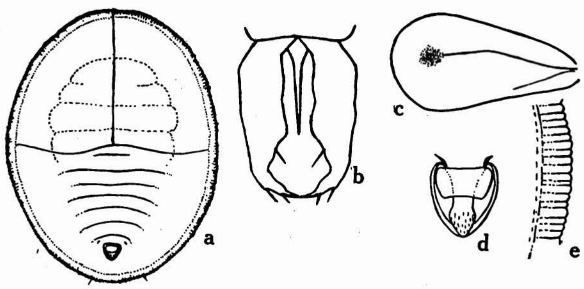


Figure 23—*Aleyrodes shizuokensis* Kuwana. **a,** pupa; **b,** male genitalia; **c,** wing; **d,** vasiform orifice of pupa; **e,** detail of margin of pupa. (Redrawn from Kuwana, 1911:621.)

Aleyrodes shizuokensis Kuwana (fig. 23, a–e).

Aleyrodes shizuokensis Kuwana, 1911:620, fig. 207, A–E.

The oxalis white fly.

Oahu.

Immigrant. A Japanese species described from Shizuoka. First noticed in Honolulu about 1925 by Swezey, but it was not recorded from the islands until 1945 (Zimmerman, *Proc. Hawaiian Ent. Soc.* 12(3):486, 1946).

Hostplant: *Oxalis.*

The eggs have very short stalks and are scattered over the leaf surface.

Aleyrodes spiraeoides Quaintance (fig. 24, a–m).

Aleyrodes spiraeoides Quaintance, 1900:36, pl. 6, figs. 45–49; pl. 8, fig. 74. (Note: The explanation of plate 6 is out of place in the text and is numbered 4.) Quaintance and Baker, 1914:100, pl. 38.

The iris white fly.

Maui.

Immigrant. Described from California. First found in the Hawaiian Islands by me at Waiakoa, Kula, Maui, in April, 1945.

Hostplants: *Iris, Moraea iridiodes.*

The short-stalked eggs are scattered over the leaf surface.

Essig (1929:327) says that in California "The species is often very abundant and quite destructive to iris, but also feeds on buckeye, fuchsia, wild lettuce, malva, morning glory, wild and cultivated honeysuckle, nightshade, ninebark, plantain, sow thistle, and wild and cultivated tobacco."

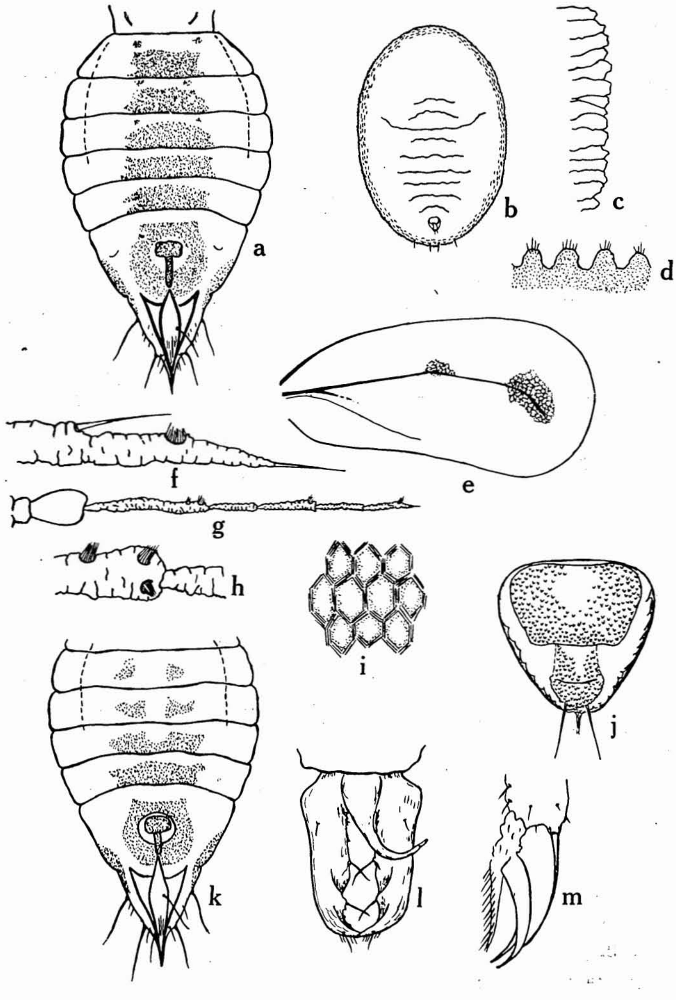


Figure 24—*Aleyrodes spiraeoides* Quaintance. **a,** dorsal view of abdomen of female, typical markings; **b,** pupa; **c,** detail of margin of pupa; **d,** detail of margin of fore wing; **e,** fore wing; **f,** distal segment of female antenna; **g,** antenna of female; **h,** distal part of third antennal segment of male; **i,** detail of pattern of maculation of fore wing; **j,** vasiform orifice of pupa; **k,** dorsal view of abdomen of female, variation in color pattern; **l,** male genitalia; **m,** claw of adult. (After Quaintance and Baker, 1914.)

Superfamily APHIDOIDEA
(Latreille, 1802) Handlirsch, 1903

Aphids, Adelgids, Phylloxerids

Some authors include four families in this section: Adelgidae, Phylloxeridae, Eriosomatidae and Aphididae. Only the two last-named groups occur in Hawaii. I have followed those workers who consider the Eriosomatidae a subfamily of the Aphididae, and thus include only a single family here.

Family **APHIDIDAE** (Buckton, 1881)

Aphids, Plant Lice

Small, mostly delicate, soft-bodied, mostly rather slow-moving (but some agile and these may jump and fly quickly), rarely immobile, sap-sucking creatures; body naked, setose, pruinose or clothed with wax; compound eyes well developed, often with lateral tubercles, or reduced to a few ommatidia, three ocelli present in winged forms; antennae filiform, three- to six-segmented, the terminal segment usually with an elongate apical style, some of the segments bearing prominent, subcircular, annular or transversely elongate sensoria; rostrum with three or four discernible segments, variable in length, its included stylets long; thorax distinct and the segments visible in the alates, but pterothorax largely fused with abdomen in apterous forms; legs variable in length, usually long and slender, tarsi normally two-segmented and bearing two claws, rarely one-segmented or wanting; wings present or absent, held roof-like or rarely flat over the abdomen when at rest, usually hyaline, rarely clouded, and delicate, fore wings usually longer than body, venation much reduced as illustrated, hind wings smaller with still fewer veins, and with hamuli or hooks which attach them to the fore wings; abdomen largely fused and without very distinct segmentation, with wax glands, hairs of various types and tubercles present or absent and with a pair of dorso-lateral, precaudal cornicles (absent in some few unusual genera) which range in their development from mere rings to greatly elongate, horn-like processes; abdomen terminating in a modified area called the anal plate, above which is situated a variformed, tail-like process known as the cauda, and beneath which is situated the genital plate; the anus opens between the cauda and anal plate.

Honeydew is a sweet fluid containing dextrin, invert sugar, sucrose and protein, and is excreted in profusion by many species. In years past, some workers thought that aphid honeydew was excreted through the cornicles—a belief still held erroneously by some persons (see Hottes, 1928:71). Thus, the cornicles

came to be called "honey tubes." However, honeydew is excreted through the anus, and the cornicles secrete a waxy or oily, possibly repugnatory, fluid, and perhaps also have an excretory function, the excretion being gaseous. Dermal glands produce the waxy powder or flocculent secretions found on various species.

The life histories of aphids are among the more complex and puzzling of those of all insects. Edith Patch said, "To attempt to epitomize the life cycle of the aphid is like trying to draw an orderly sketch of Chaos" (1920:156; this paper is most interesting and readable). However, here in tropical Hawaii, much of the complexity of the aphid habits and life histories is eliminated. This may be accounted for on the basis of our "perpetual summer," which lacks the potent seasonal influences of the temperate zones. Here aphid species from four-season climes assume their warm weather forms throughout the year and, insofar as we know, stay on their summer hosts with no alternation of hostplants.

Because we are not confronted with complicated and confusing aphid cycles in Hawaii, and because readily available textbooks have assembled the information in detail, we need not devote much space to that phase here. For comparative purposes, however, a cursory outline of some of the salient features of aphid biology outside the tropics will be helpful to the reader.

Mordvilko (1928) said:

> The plant-lice originated in a moderate climate. Such a statement is before all based upon the fact that the great diversity of forms (subfamilies, tribes, genera) is observed in moderate latitudes, whereas in Tropics the number of groups and genera decreases considerably, and there are no endemic genera that do not occur in subtropical or even moderate climates as well. Moreover, plant-lice are characterised by heterogeny—*i.e.*, a succession of virgin generations with one amphigon terminating the cycle. However, in Tropics the bisexual generation falls out entirely, and this is undoubtedly a secondary phenomenon, the reproduction of plant-lice having originally been only bisexual.... (p. 570). At different epochs of the history of the earth the evolution of cycles in plant-lice proceeded and is still proceeding in one and the same way, and such a uniformity of the course of evolution may be explained only by the peculiarities of the climate in moderate latitudes with their seasons and periodical phenomena of vegetation. The fundatrices are adapted to spring conditions of vegetation, whereas the bisexual generation and fertilized eggs serve to withstand the unfavourable winter conditions. In fact, when plant-lice reach the Tropics with their constant even climate, their cycle becomes much simplified, the bisexual generation and fundatrices fall out, only wingless and winged virgins remaining. Heteroecy [alternation of hosts] in Tropics is impossible, it can hardly stand even if it will be transported there from moderate latitudes (p. 582).

Aphids exhibit remarkable differences in habit, hostplant selection, seasonal host preferences, reproduction, form and alternations of generations. Parthenogenesis is the principal method of reproduction. In some generations males are never produced, in others they may be greatly in the minority and produced at only certain times of the year. Some female forms produce eggs; others are ovoviviparous. The reproductives may be winged in one generation and not in the next. There is a remarkable alternation of hostplants in some species. For example, the mealy plum aphid which is a well-known pest of plums and prunes, over-winters on the fruit trees in the egg stage. From the eggs hatch apterous, parthenogenetic "stem mothers" which give rise to apterous, parthenogenetic, vivi-

parous females. After reproducing on the fruit trees in the spring, summer migrants are produced. These leave the fruit trees in the late spring and early summer (although some apterae may remain on the fruit trees until winter) and migrate to reeds and cat-tails where alate and apterous, viviparous females are produced. In the fall, another migrating generation is produced which transfers back to the fruit trees where males and oviparous females produce eggs for overwintering. Hottes and Frison (1931:135) record that in Illinois

Hamamelistes spinosus Shimer hibernates on white birch in the form of greatly modified individuals... resembling coccids more than they do aphids; descendants of these hibernating coccid-like aphids fly in early spring to witch-hazel, upon which the sexual forms are produced. The eggs are soon laid but do not hatch until May or June of the following year. Descendants of the individuals hatching from the over-wintering eggs on witch-hazel migrate to birch, where other generations soon modify themselves into the coccid-like individuals mentioned above. Thus this species spends the winter on both of its hosts but in two different ways.

Professor Essig informs me that *Aphis persicae-niger* Smith hibernates as immature forms on plum trees in the San Francisco Bay area of California.

Coupled with these changes of hosts and generations and sexual forms is great polymorphism, which may be most confusing to the student. Males may be produced or not and may be fully winged or apterous; some parthenogenetic, ovoviviparous females are winged, many are apterous, and the features of the alates may be considerably different from those of the apterae. Individuals which have aborted mouth parts may be produced in some generations in some species. This summary does not cover the full range of variability in habit, form and structure of the aphids.

No one has yet reported seeing a male aphid or an aphid egg in Hawaii. All the information we have indicates that the species recorded from the Hawaiian Islands reproduce parthenogenetically by ovoviviparity. We do not know that any species here has an obligate seasonal alternation of hostplants. We have, then, only three life forms beyond the egg for most of our aphids. These are: nymphs; winged, ovoviviparous, parthenogenetic females; and apterous, ovoviviparous, parthenogenetic females. However, in two genera represented in Hawaii, *Cerataphis* and *Thoracaphis,* another form is encountered. It is the aleyrodid-like stage of the most common form of apterous female of the species. This stage is not infrequently confused with aleyrodids or scale insects. In contrast to this state of affairs, however, all the aphids of regions of cold winters have bisexual reproduction and lay eggs at least in the concluding generation of each year.

The reproductive potential of aphids is well known, and there has been much written about their generative speed and ability. Buckton (1876:80–81) calculated that a single female aphid laying an egg a day for 20 days could give rise at the end of 300 days to the theoretical and astounding total of 210^{15} individuals (in the neighborhood of 68,122,300,000,000,000,000,000,000,000,000,000), providing they had ample food, were not attacked by predators, not parasitized, and were otherwise left undisturbed to increase without check. As he notes, "There would

be room in the world for nothing else but Aphids!" The speed with which they are capable of reproducing not infrequently leads agriculturists to believe that their crops have become heavily infested in a few days or overnight. The fact is that with such geometric increase, the first few generations may not be noticed, but later generations will seem to appear suddenly, because their great numbers make them obvious to even casual observation.

The Hawaiian Islands are without an endemic aphid fauna. Only one of the 47 species of aphids now listed from the archipelago is of doubtful origin, *Vesiculaphis caricis* (Fullaway). This aphid, I believe, will be found elsewhere as the Aphididae of other areas become better known. The islands have been scoured from bottom to top by many skilled entomologists, and the lack of a native aphid fauna is in no way connected with inadequate collecting. We do know, however, that other species not listed here occur in the islands and that more attention paid to collecting on imported plants especially will reveal the presence of other immigrant aphids. Perkins, in his introduction to *Fauna Hawaiiensis* (1913:ccx), stated that

> The members of this family are of little or no interest faunistically, since probably all of them have been imported with introduced plants. In this connection however it is proper to state that formerly, 1892–1896, a species of *Myzus* (?) was very abundant throughout the mountains, especially attacking the species of *Pelea*, other species of Aphids being hardly met with in the forests at the earlier date. This *Pelea*-frequenting species seems to have been practically exterminated by the ladybirds (especially *Coelophora inaequalis*) introduced to diminish the attacks of foreign Aphids, on which *Coelophora* now maintains itself in the mountains. [Note: In my opinion, this aphid species was possibly *Toxoptera aurantii*, which see.]

Timberlake (1924:450) said, "... there is no absolute certainty that there was any aphid fauna at all in the Islands before the establishment of commercial relations with the outside world in the early part of the nineteenth century."

Hawaii is not alone in its lack of native aphids; this faunal deficiency is shared by most of the other islands of Oceania, and New Zealand and Australia are in almost the same category. A single presumably native aphid has been described from Australia (*Anomalaphis comperei* Pergande, Baker, 1920:52), and one from New Zealand (*Aphis coprosmae* Tillyard). Professor Essig, however, tells me that he has examined specimens of *Aphis coprosmae* collected by Tillyard and that the species appears to be the widespread *Aphis gossypii* Glover. Further collecting is necessary to elucidate the status of these species, but even if they are endemic, it is obvious that in New Zealand and Australia the native aphid fauna is almost nil. Takahashi (1934) described *Aphis mumfordi* from a few, inadequate, apterous specimens from the Marquesas Islands, but I feel that in all probability the insect described is an immigrant and may well be a common, widespread species. There are no "native" aphids recorded from the other Polynesian islands. The family has its greatest development in the Holarctic region.

The oldest known fossil aphid is *Canadaphis carpenteri* Essig, which was described in 1937 from Canadian amber from Cretaceous deposits.

According to Essig (1942:337) there are about 2,000 known species of aphids assigned to about 150 genera.

Aphids are among the most destructive insects the agriculturist has to contend with. No parts of some kinds of plants are exempt from their attacks, for there are species that live on roots, stems, bark, leaves, shoots, flowers and fruits. The reproductive potential of some species is enormous, and in a matter of a few days a new planting may be so badly infested that crop failure results. Not only do aphids injure plants by constant pumping out of the vital plant sap, sometimes causing them to wither and dry up, develop abnormal growths or become stunted and poor producers, but many of them are potential or actual vectors of plant virus diseases.

The quantities of honeydew they produce often provide culture media for the development of smut fungi which badly disfigure the plants, their flowers, leaves and fruits. Also, this sweet fluid frequently furnishes a large part of the food of local ant populations and results in an increase of ants which in turn may favorably influence the dispersal and increase of the aphids. Ants are known to pick up and transfer aphids from one part of a plant to another and from plant to plant. Ants also have an adverse influence on the parasites and predators of aphids, for they may interfere with parasitism and drive off or kill the parasites and predators. Ants "milk" aphids by stroking them, thus inducing them to excrete globules of honeydew. In fact, ants treat aphids much as men treat milch cows, for they herd them, protect them, build barns of detritus over them, transfer them to new pastures and milk them.

Aphids are attacked by a large number of parasites and predators. In Hawaii these include braconid and aphelinid wasps, green and brown lacewings, syrphid flies, an ochthiphilid and a cecidomyiid fly, a variety of coccinellid beetles and other less well-known predators.

Control: In Hawaii it has been found that nicotine sulphate sprays ("Black Leaf 40," etc.) or nicotine dusts ("Nicodust," etc.) are to be recommended generally for the control of aphids. If such commercial products are not available, a warm soap solution, easily made from laundry soap powder or chips, makes a good spray. It is cheap, easy to prepare and non-poisonous to man. The control of ants also will aid in keeping down aphid populations. Spraying must be repeated at intervals because reinfestations occur rapidly, and populations may build up quickly after spraying. Aphids usually must be hit by the spray to be controlled.

The aphids are a particularly difficult group to work with for a number of reasons. They are confusing taxonomically. They are not easy to prepare properly for study. Their habits have resulted in the aphid faunas of the world's zoogeographical regions becoming extensively mixed up because the aphids have been carried widely by man in his commerce. This has resulted in extensive synonymy. Many species display a wide and confusing range of individual variability of various kinds and degrees. Their economic importance has encouraged many workers who have looked upon systematics more as a mere method of applying a name-tag to an animal than as an interpretation of phylogeny and evolution to enter the

field of aphid taxonomy. This has given rise to a mass of supraspecific categories which lack coherence and lucidity and which are little short of chaotic.

Because I have been unable to find any of the well-known studies on aphids suitable for the species we have in Hawaii, I have abandoned any attempt to key out our species by subfamilies, tribes and other suprageneric categories. A single key is presented here to include all the genera, and it contains dichotomies based upon the more obvious characters without special regard for segregation into supra-generic groups. I feel that this procedure will prove more useful and will be more easily comprehended by local students dealing with our limited, adventive fauna than if a classification used elsewhere were adopted. However, in the main text following the generic key I have arranged the genera in accordance with the recent classification of Gillette and Palmer (1931–1934) and Palmer (1936), but I have given no descriptions of the suprageneric categories. Such information can be obtained from the papers of Baker, Gillette and Palmer, Hottes and Frison and other workers, but the student will find that not all authorities agree as to diag-nostic characters of each group.

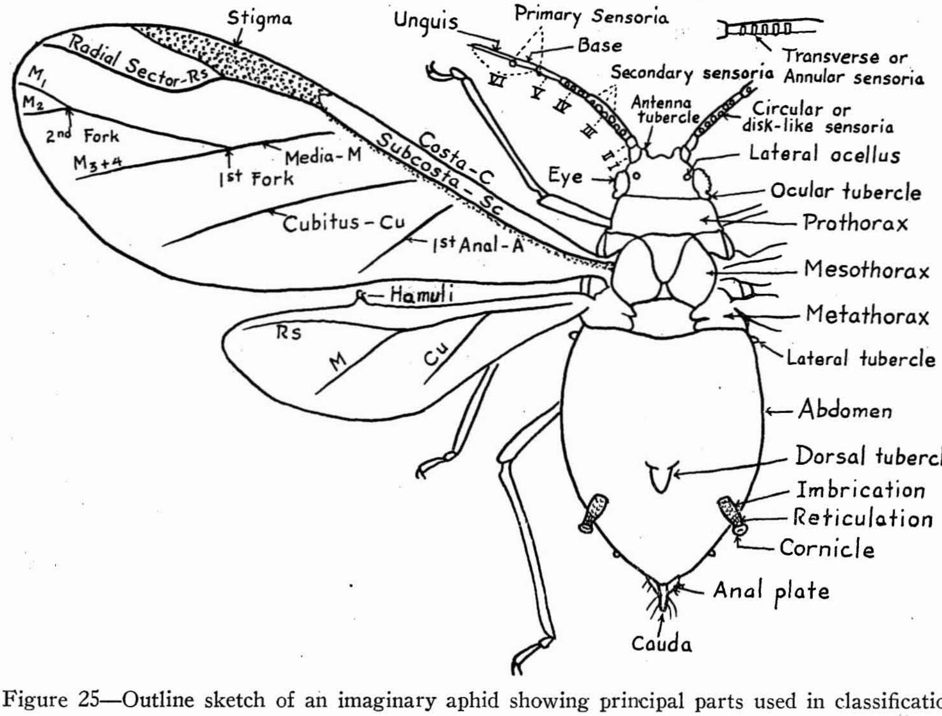


Figure 25—Outline sketch of an imaginary aphid showing principal parts used in classification.

When using any text concerning aphids, one must always keep in mind the variability of the individuals of any given species and further realize that slide-mounted specimens have certain limitations as objects for study. Thus, more than a single example frequently may be required to enable one to use the keys with success. Fortunately, because of their gregarious habits, it is usually not difficult

to obtain good series of aphids, and one may thus mount a series of examples from which to obtain an "average" of the specific characters. Poorly prepared specimens and specimens improperly oriented in a slide mount may lead one astray or cause considerable confusion. Excellent slide mounts of aphids can be made by those who are willing to take the time to prepare them, but many workers are often in too much haste or are simply negligent or are unfamiliar with mounting technique. If in using the following keys you cannot seem to run your example, try another specimen, for a badly oriented, shriveled or defective specimen may easily lead to misidentification.

Key to the Genera of Aphididae Known to Occur in Hawaii

1. Alates 2
   Apterous viviparous females 22

2(1). Sensoria on third antennal segment transverse or annular (cornicles usually obsolete, but if distinct, then shorter than cauda) 3
   Sensoria on third antennal segment sub-circular or disc-like (cornicles almost always distinct and usually longer or much longer than cauda, but much reduced in *Lachnus* and *Tuberolachnus*) 7

3(2). Media of fore wings with only a single branch 4
   Media of fore wings with two branches 6

4(3). Antennae six-segmented; both winged and apterous forms produce masses of wax; no aleyrodid-like forms .... **Eriosoma** Leach.
   Antennae five-segmented; with aleyrodid-like apterous forms 5

5(4). Dorsum with long, prominent setae as in figure 83 .... **Thoracaphis** Van der Goot.
   Dorsum without such setae; as in figure 81 .... **Cerataphis** Lichtenstein.

6(3). Body tuberculate, tubercles normally bearing stout setae; cornicles produced; third antennal segment with few sensoria (six in our species); fore wings with Rs obsolete in our species .... **Myzocallis** Passerini.
   Body not tuberculate; cornicles ring-like; third antennal segment with numerous sensoria; fore wings with Rs distinct .... **Neophyllaphis** Takahashi.

7(2). Antennae five-segmented .... **Cerosipha** Del Guercio.
   Antennae six-segmented 8

8(7). Body, including cornicles and antennae, conspicuously hirsute (cornicles greatly reduced) 8a
   Not such hairy insects 9

8a(8). Abdomen without a dorsal tubercle; radial sector of fore wings obviously curved; on conifers .... **Lachnus** Burmeister.
   Abdomen with a prominent, median, dorsal tubercle (see fig. 27); radial sector of fore wings only slightly arcuate, nearly straight; not on conifers .... **Tuberolachnus** Mordvilko.

9(8). Fore wings with Rs following an abnormal course, directed posteriorly to M, and nearly or obviously fused with M for a varied length, thus making or nearly making a closed cell between stigma and M (figs. 78, 79) 10
Fore wings without such abnormal venation 11
10(9). Vein Cu present in hind wings; fore wings without a distinct closed cell between stigma and media (fig. 79) and not as described below .... **Idiopterus** Davis.
Hind wings lacking vein Cu; fore wings with a conspicuous closed cell between media and stigma, and Rs joined to M between first and second forks of M in such a manner that it appears that M has three forks (fig. 78) .... **Pentalonia** Coquerel.
11(9). Fore wings with media with only one fork 12
Fore wings with two forks to media 13
12(11). Cornicles tapering from base .... **Toxoptera** Koch.
Cornicles swollen, subapically constricted .... **Vesiculaphis** Del Guercio.
13(11). Abdomen with a tubercle or horn-like protuberance above cauda (fig. 52) .... **Cavariella** Del Guercio.
Abdomen without such a process 14
14(13). Head with well-developed frontal tubercles (cornicles usually, but not always, long or very long and slender) .. 15
Head without prominent frontal tubercles (cornicles rarely as much as twice as long as cauda) 19
15(14). Frontal tubercles produced as a finger-like process; first antennal segment swollen and projecting medianly (see fig. 75) .... **Phorodon** Passerini.
Not so 15a
15a(14). Head and two basal antennal segments with conspicuous capitate bristles .... **Capitophorus** Van der Goot.
Without such bristles 16
16(15a). Cornicles subbasally constricted, then swollen and either thicker at about middle or beyond, or nearly so (if the constriction and swelling are rather indefinite in combination with wings that are not infuscate along the veins, then go to 18) 17
Cornicles thickest at base and not conspicuously swollen at middle but usually tapering distad (some specimens of *Myzus persicae* may cause confusion here); see figures 66–74 18
17(16). Wings infuscate along veins; cauda tapering rather evenly and not strongly constricted .... **Micromyzus** Van der Goot.
Wings not infuscate along veins; cauda distinctly constricted at about middle .... **Amphorophora** Buckton.
18(16). Derm of inner sides of frontal tubercles, especially, imbricated or asperate (pronounced in apterae) .... **Myzus** Passerini.
Derm of frontal tubercles smooth and not at all imbricated .... **Macrosiphum** Passerini.
19(14). Cornicles swollen and/or short or very short, not as long as diameter of cauda 20

Cornicles tapering or clavate, but more elongate, in most species somewhat longer or much longer than diameter of cauda, usually much longer than cauda.............21

20(19). Cornicles very small, tubercle-like, less than twice as long as broad in our species, much shorter than cauda .... **Brachycolus** Buckton.

Cornicles about as long as cauda, twice as long as broad in our species................**Brevicoryne** Van der Goot.

21(19). Cornicles subcylindrical or tapering........**Aphis** Linnaeus.

Cornicles more or less swollen or post-medianly swollen and constricted before apical flange (figs. 54–57).......21a

21a(21). Hairs on body not capitate...........**Rhopalosiphum** Koch.

Hairs on body capitate (best seen when cleared and stained) ....**Coloradoa** Wilson.

APTEROUS VIVIPAROUS FEMALES

22(1). Aleyrodid-like forms 23

Not aleyrodid-like forms.................................24

23(22). As in figure 81; head with a pair of horn-like processes on vertex; on orchids and palms................. ....**Cerataphis** Lichtenstein.

As in figure 84; head without such processes; on *Ficus* ....**Thoracaphis** Van der Goot.

24(22). Cornicles mere rings or hardly elevated, or on the apex of broad cone-like bases.............................25

Cornicles tuberculiform or elongate.....................28

25(24). Antennae four- or five-segmented......................26

Antennae six-segmented 27

26(25). Lateral margins of body conspicuously serrated; vertex of head with two small horn-like processes; cauda transverse ....**Cerataphis** Lichtenstein.

Lateral margins of body not serrated; vertex unarmed; cauda elongate...............**Neophyllaphis** Takahashi.

27(25). Body and appendages sparsely setose; cornicles not on cone-like bases.......................**Eriosoma** Leach.

Body and appendages conspicuously hairy; cornicles on broad cone-like elevations (figs. 26, 27).............27a

27a(27). Abdomen without a median dorsal tubercle........... ....**Lachnus** Burmeister.

Abdomen with a large median dorsal tubercle.......... .... **Tuberolachnus** Mordvilko.

28(24). Abdomen with a conspicuous, horn-like projection above cauda (fig. 52).................**Cavariella** Del Guercio.

Abdomen without such a process......................29

29(28). Frontal tubercles each produced into a finger-like process; first antennal segment produced inwardly....... ....**Phorodon** Passerini.

Not so 29a

29a(29). Body with numerous, usually conspicuous, capitate or clavate setae (check carefully under high power, or you may be misled especially by *Pentalonia* and *Coloradoa* (figs. 57, 63, 78, 79)..............................30

Body without such setae..............................33

30(29a). Median part of front of head produced beyond anterior edges of bases of first antennal segments; body with unusually large, robust, conspicuous dorsal and lateral tubercles (fig. 30) . . . . **Myzocallis** Passerini.

Median part of front of head not extending as far forward as anterior edges of first antennal segments; body without such stout tubercles 31

31(30). Many of the capitate setae on dorsum paired (fig. 79) . . . . **Idiopterus** Davis.

Capitate setae always single 32

32(31). Frontal tubercles distinctly protuberant (fig. 78) . . . . **Pentalonia** Coquerel.

Frontal tubercles not protuberant (figs. 57, 64) 32a

32a(32). Cauda not constricted . . . . **Capitophorus** Van der Goot.

Cauda constricted . . . . **Coloradoa** Wilson.

33(29). Antennae five-segmented; top of head expanded to form a ledge which conceals antennal insertions (fig. 60) . . . . **Vesiculaphis** Del Guercio.

Antennae five- or six-segmented, but head not so peculiarly formed 34

34(33). Antennae five-segmented . . . . **Cerosipha** Del Guercio.

Antennae six-segmented 35

35(34). Head with prominent frontal tubercles (as in figs. 76, 77) . . 36

Frontal tubercles neither distinctly developed nor protuberant (figs. 31–51) (Note: This is not always as definite a character as desired; use caution here.) 39

36(35). Cornicles conspicuously swollen, as in figures 61, 62, 76, 77 . . 37

Cornicles not swollen, as in figures 66–74 38

37(36). Cauda not or hardly constricted before base; frontal tubercles conspicuously protuberant (figs. 76, 77) . . . . **Micromyzus** Van der Goot.

Cauda conspicuously constricted; frontal tubercles not so protuberant in our species (figs. 61, 62) . . . . **Amphorophora** Buckton.

38(36). Frontal tubercles with derm imbricate or asperate (fig. 71) . . . . **Myzus** Passerini.

Derm on frontal tubercles smooth (fig. 70) . . . . **Macrosiphum** Passerini.

39(35). Cornicles not longer than cauda, or distinctly shorter 40

Cornicles longer than cauda, usually much longer 42

40(39). Cornicles much shorter than cauda . . . . . **Brachycolus** Buckton.

Cornicles about as long as cauda 41

41(40). Cornicles somewhat swollen . . . . . . **Brevicoryne** Van der Goot.

Cornicles cylindrical or tapering . . . . **Aphis** Linnaeus.

42(39). Cornicles somewhat swollen or clavate 43

Cornicles cylindrical and tapering 44

43(42). Body hairs not capitate . . . . **Rhopalosiphum** Koch.

Body hairs capitate . . . . **Coloradoa** Wilson.

44(42). **Aphis** and **Toxoptera**; these two genera appear to be separated only by the fact that media in the fore wings is twice-branched in *Aphis,* whereas it has only one branch in *Toxoptera.*

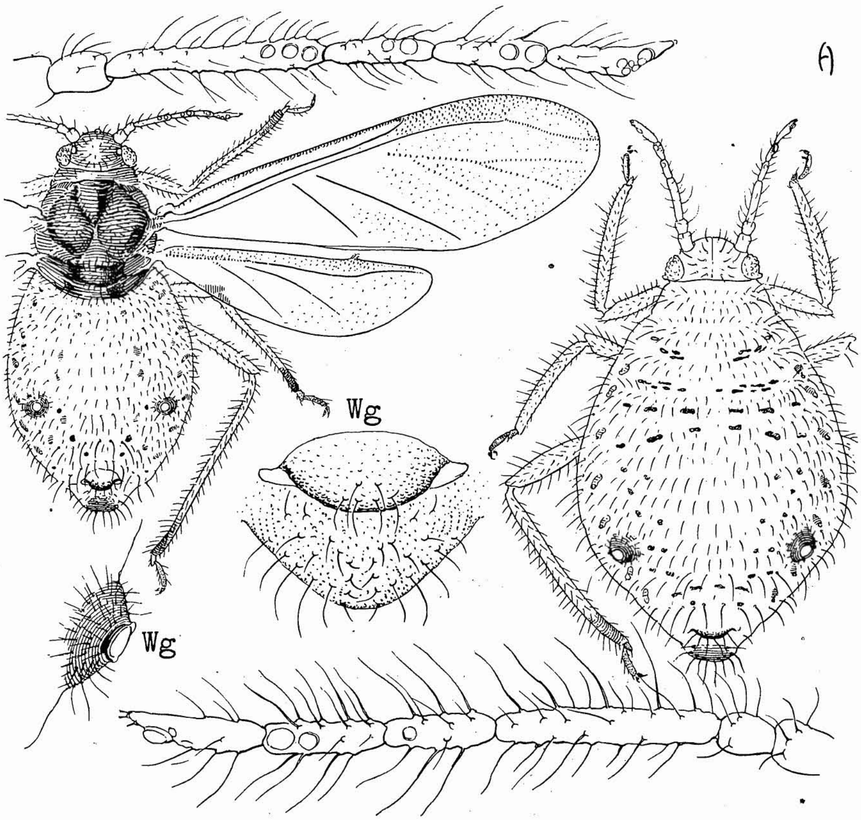


Figure 26—*Lachnus tujafilinus* (Del Guercio). (Drawn by Abernathy.) Where abbreviations are used on the figures of the aphids **Wg** refers to the winged form and **Ap** to the apterous form. The antennae enlarged at the tops of the figures belong to the winged adult, those at the bottom to the apterae.

Subfamily APHIDINAE

Tribe LACHNINI

Subtribe Lachnina

Genus LACHNUS Burmeister, 1835

Pterochlorus Rondani, 1848. See Hottes, 1930:185.

Among all the aphids now present in Hawaii, this genus and *Tuberolachnus* are outstanding because of their conspicuously hairy bodies and appendages. The antennae are six-segmented in the apterae and winged forms, the cornicles are slightly elevated rings on broad conical bases, there are no frontal tubercles, the secondary sensoria on the third antennal segment are circular, the cauda is a low,

broad, arcuate lobe, the hind wings have both M and Cu present, and M in the fore wings has two forks.

Lachnus tujafilinus (Del Guercio) (fig. 26).
Lachniella tujafilina Del Guercio, 1908:311, pl. 17, figs. 204–207.

The juniper aphid.

Oahu.

Immigrant. A widespread European species. First found in the Territory at Honolulu by Ehrhorn in 1924.

Hostplants: *Thuya occidentalis, Thuya orientalis* (arbor vitae), *Juniperus chinensis.*

Few records of the capture of this species in the Hawaiian Islands are available, but it is taken occasionally. Its hirsute body and appendages will distinguish it. The apterae, which I have seen alive, are brownish in body color, covered with white meal, have two dark dorsal stripes, two dark bands connecting cornicles, a dark lateral stripe from each cornicle to cauda, and the legs are pale with dark tarsi. It is one of our most distinctive aphids.

Genus **TUBEROLACHNUS** Mordvilko, 1909

Unusually large species for our fauna (a centimeter or more in expanse); antennae hairy, six-segmented in alates and apterae, secondary sensoria circular to oval, large, strongly convex; cornicles broad and low; abdomen with a prominent, median, dorsal, cone-like tubercle; cauda broadly rounded; fore wings with two forks to M and with radial sector only slightly arcuate, nearly straight, M and Cu present in hind wings; body conspicuously hairy; the species feed on the woody parts of their hostplants.

Tuberolachnus salignus (Gmelin) (fig. 27).
Aphis saligna Gmelin, in Linnaeus, Systema Naturae, edition 13, 1(4):2209, 1790.

Hawaii.

Immigrant. Widespread in the Northern Hemisphere. First found in the Hawaiian Islands by W. M. Giffard at Kilauea, Hawaii, 4,000 feet, on August 19, 1911. On January 15, 1917, Giffard and Muir took it at Kahuku, Kau, Hawaii. It remained unidentified and unrecorded in Hawaii until 1946, when fresh material collected by A. C. Davis was sent to Essig for determination.

Hostplant: *Osteomeles anthyllidifolia.*

This is the largest species of aphid known from our region—it may measure 13 mm. in expanse. The peculiar, prominent, dorsal abdominal process is a further aid to its identification.

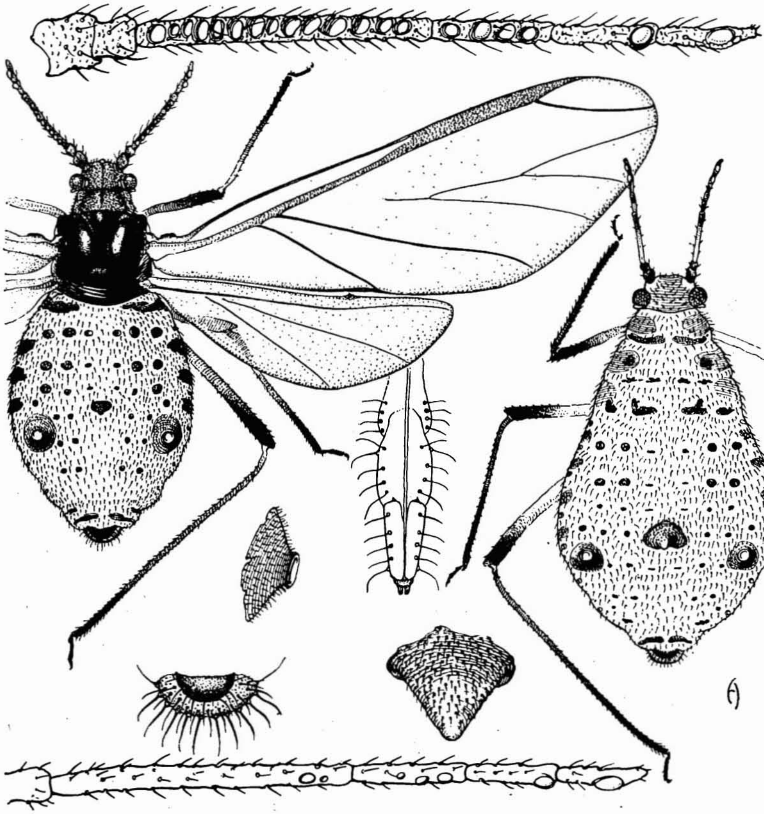


Figure 27—*Tuberolachnus salignus* (Gmelin). (Drawn for this text by Abernathy through the courtesy of E. O. Essig and the Division of Entomology, University of California.)

It has been found feeding on the bark of its host here, and it is a common pest of willows in some places in the United States. Hottes and Frison (1931:159) say that it is restricted to willow in Illinois. Patch (1938:83, 151) lists it from *Populus, Prunus* and *Pyrus* in addition to *Salix*. *Osteomeles* belongs to the Rosaceae.

Tribe CALLIPTERINI

Subtribe PHYLLAPHIDINA

Genus **NEOPHYLLAPHIS** Takahashi, 1920

This is one of the more distinctive aphid genera in our fauna. In the winged forms the antennae are six-segmented, but they are only five-segmented in the

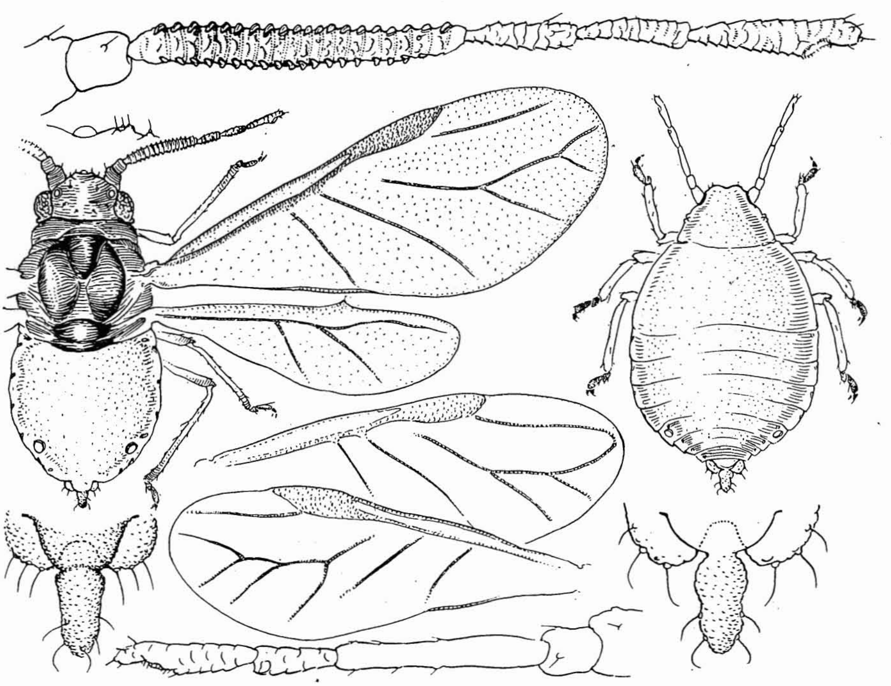


Figure 28—*Neophyllaphis araucariae* Takahashi. The araucaria aphid. Sketches of a fore wing of each of two other individuals show variation in venation. (Drawn by Abernathy.)

apterae, and the third antennal segments of the alates have narrow transverse sensoria. The cornicles are mere rings, the cauda is elongate and constricted, the hind wings have M and Cu present, and M in the fore wings has two forks.

Neophyllaphis araucariae Takahashi (figs. 28, 29).
Neophyllaphis araucariae Takahashi, 1937:105, 1 fig.

The araucaria aphid.

Kauai, Oahu, Molokai, Maui.

Immigrant. Described from Mauritius. First found in the Hawaiian Islands by Timberlake at Honolulu in 1916.

Hostplant: *Araucaria excelsa* (Norfolk Island pine).

Predators: *Coelophora inaequalis* (Fabricius) (Coleoptera: Coccinellidae); *Chrysopa lanata* Banks (Neuroptera: Chrysopidae).

The illustrations clearly demonstrate the salient characters of this species. The eyes on the apterae are considerably reduced; the anal plate is bilobed; the supplementary sketches of wings show anomalies in venation; the aphids are yellow in body color.

Occasionally this species builds up numerous colonies on young trees, but it is usually quickly brought under control by ladybird beetles.

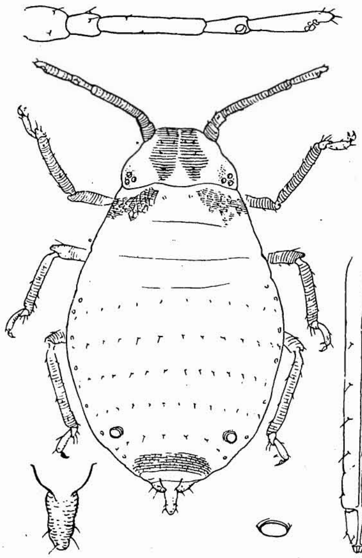


Figure 29—*Neophyllaphis araucariae* Takahashi. The araucaria aphid. Details of the apterous form. (Drawn by Abernathy.)

Subtribe CALLIPTERINA

Genus MYZOCALLIS Passerini, 1860

The heavily tuberculate body gives this genus a distinctive appearance. The antennae are six-segmented in both alates and apterae, and in the winged forms the sensoria on the third antennal segment are transversely suboval and of a characteristic shape. The cornicles are short and tuberculiform, the cauda is strongly constricted, the anal plate is bilobed, M in the fore wings is twice forked and M and Cu are present in the hind wings. The tubercles on the apterae bear conspicuous capitate setae, but in the alates these setae are not capitate and are not especially conspicuous.

Myzocallis kahawaluokalani Kirkaldy (fig. 30).
Myzocallis kahawaluokalani Kirkaldy, 1907:101.

The crepe myrtle aphid.

Oahu (type locality: Honolulu).

Immigrant. Described from the Hawaiian Islands but known from China, Formosa, Japan and North America.

Hostplant: *Lagerstroemia indica* (crepe myrtle).

According to Dr. Swezey, it is doubtful that Kirkaldy preserved any of his type material, and it may be that he destroyed the type series after he described the species.

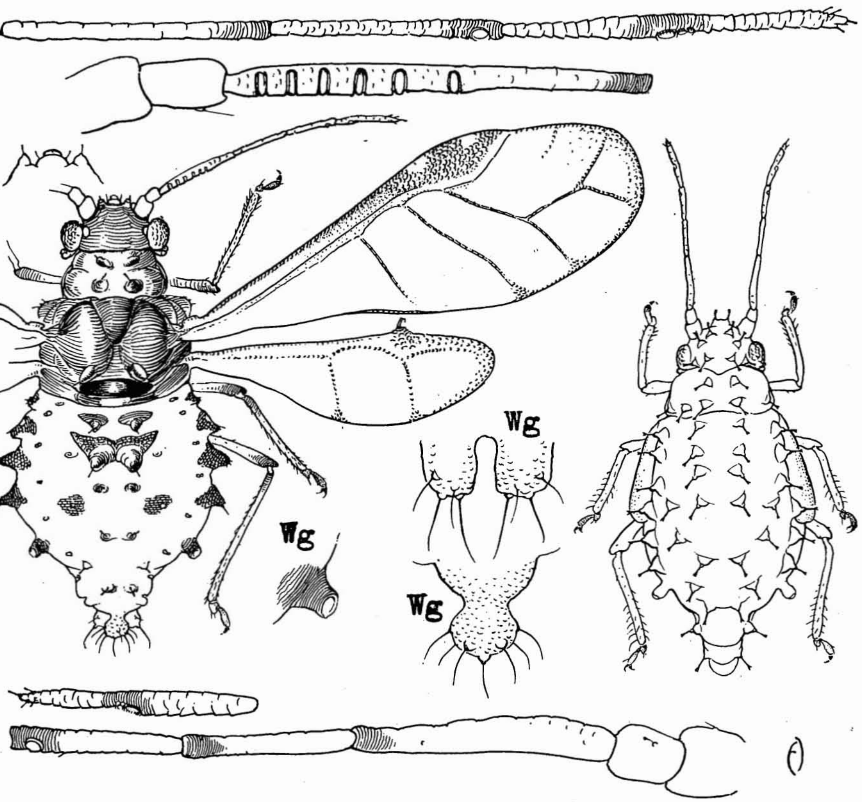


Figure 30—*Myzocallis kahawaluokalani* Kirkaldy. The crepe myrtle aphid. (Drawn by Abernathy.)

Kahawaluokalani was a chief on the island of Kauai. The name means "The Eight Divisions of Heaven," according to my friend Mrs. Kawena Pukui.

This is a striking species. In life the body of the winged form is pale yellowish-green with strongly contrasting black marks which give it a conspicuous multi-maculate and harlequin appearance; the tips of the antennal segments are dark, and the dark pattern on the wings is prominent; there is a remarkable, two-pronged hump near the base of the abdomen. The wings, when at rest, instead of being held very close together vertically and slanting steeply, are laid much more flatly oblique over the abdomen than are those of most aphids. The apterae are yellowish-green with the tips of the antennae, tops of most of the body tubercles and the setae they bear dark or black.

Dozier (*Jour. Econ. Ent.*, 19:800, 1926) noted that this is the most serious enemy of the widely planted ornamental crepe myrtle in the gulf states of North America and "at times produces complete defoliation or renders the foliage unsightly by the black sooty mold that grows in the 'honey dew' excretion." He records a species of *Chrysopa* and the ladybird beetle, *Olla abdominalis sobrina* Casey, as preying on it there. We do not often collect it in Hawaii.

Takahashi, in his work on the aphids of Formosa, placed this species at various times in *Monellia, Callipterus* and *Agricaphis.* In his 1931 paper (p. 84) he gives the synonymy.

Tribe APHIDINI

Subtribe Aphidina

Genus **APHIS** Linnaeus, 1758:451

This is the largest assemblage of aphids in Hawaii and is not an easy group to deal with. The range of specific variability is great and one may be confused easily when attempting to assign some of the forms to genus or to species. The species as a whole have fewer conspicuous differential characters than do most of our other aphids. The antennae are six-segmented in both the alatae and apterae, and the third segment of the antennae of the alates has prominent circular or subcircular sensoria. The cornicles range in size from about the length of the cauda to much longer than the length of the cauda and are usually subcylindrical or tapering in shape. The cauda varies in shape among the species; the anal plate is rounded; M in the fore wings is twice-branched and both M and Cu are present in the hind wings; the frontal tubercles are obsolete or feebly developed; the body setae are inconspicuous in most forms, but on others they are well marked.

Key to the Species of Aphis Recorded from Hawaii

1.	Alatae	2
	Apterous viviparous females	12
2(1).	Terminal filament of sixth antennal segment somewhat longer or much longer than third segment	3
	Terminal filament of sixth antennal segment either distinctly shorter than third segment or subequal in length, never distinctly longer	7
3(2).	Cornicles short, hardly more than twice as long as broad	4
	Cornicles elongate, distinctly more than twice as long as broad	5
4(3).	Fourth antennal segment with few or no sensoria, third segment with about seven sensoria; setae on abdomen minute; cauda almost evenly conical; on sugarcane	**sacchari** Zehntner.
	Fourth antennal segment with numerous sensoria, third segment with more than 10 sensoria; setae on abdomen long and conspicuous; cauda conspicuously constricted; on bamboo	**bambusae** Fullaway.
5(3).	Fourth antennal segment with about four sensoria; cornicles with imbrications poorly developed or obsolete distad; cauda with only about two hairs on each side	**avenae** Fabricius.

Fourth antennal segment with one or no sensoria; cornicles strongly imbricated from base to apex; cauda usually with more than two hairs on a side............ 6

6(5). Length of body only about 1 mm.; distance along M between first and second fork at least twice as great as distance from second fork to wing margin; front margin of head between antennae evenly convex or nearly so and without evident frontal tubercles..**gossypii** Glover.

Body over 2 mm. long; distance between first and second fork of M only about as great as distance from second fork to wing margin; inter-antennal margin of head conspicuously sinuous transversely, the frontal tubercles developed...................**citricidus** (Kirkaldy).

7(2). Cornicles without any evident imbricate sculpturing (fig. 38)..............................**helichrysi** Kaltenbach.

Cornicles with conspicuous imbricate sculpturing......... 8

8(7). Cornicles about as long as or longer than third antennal segment; (cauda with only three hairs on each side) ....**medicaginis** Koch.

Cornicles much shorter than third antennal segment; (cauda with two to five or more hairs on each side)..... 9

9(8). Cauda with only two or three hairs on each side (do not count apical one if present)............................10

Cauda with five or more hairs on each side..............11

10(9). Cauda comparatively short and stout, about as broad as long; dorsal disc of abdomen with extensive dark coloration..........................**ferruginea-striata** Essig.

Cauda elongate, longer than broad; dark coloring of dorsum of abdomen confined to lateral and caudal patches, disc not dark.....................**maidis** Fitch.

11(9). With more than 12 secondary sensoria on third antennal segment more or less scattered irregularly all around the segment; fourth segment usually with several sensoria..............................**rumicis** Linnaeus.

With usually about seven, rarely as many as 10, secondary sensoria on third antennal segment, all or nearly all confined to a single row on posterior side of segment; fourth segment usually with only one sensorium, sometimes with two or three.............**middletonii** Thomas.

APTEROUS FEMALES

12(1). Terminal filament of sixth antennal segment longer than third segment 13

Terminal filament of sixth antennal segment shorter than third segment, at most subequal in length to third......17

13(12). Cornicles distinctly shorter than third antennal segment...14

Cornicles about as long as or longer than third antennal segment 16

14(13). Cornicles almost three times as long as their basal breadth, imbricate sculpturing obsolete..........**avenae** Fabricius.

Cornicles much shorter, not twice as long as broad, imbricate sculpturing distinct...........................15

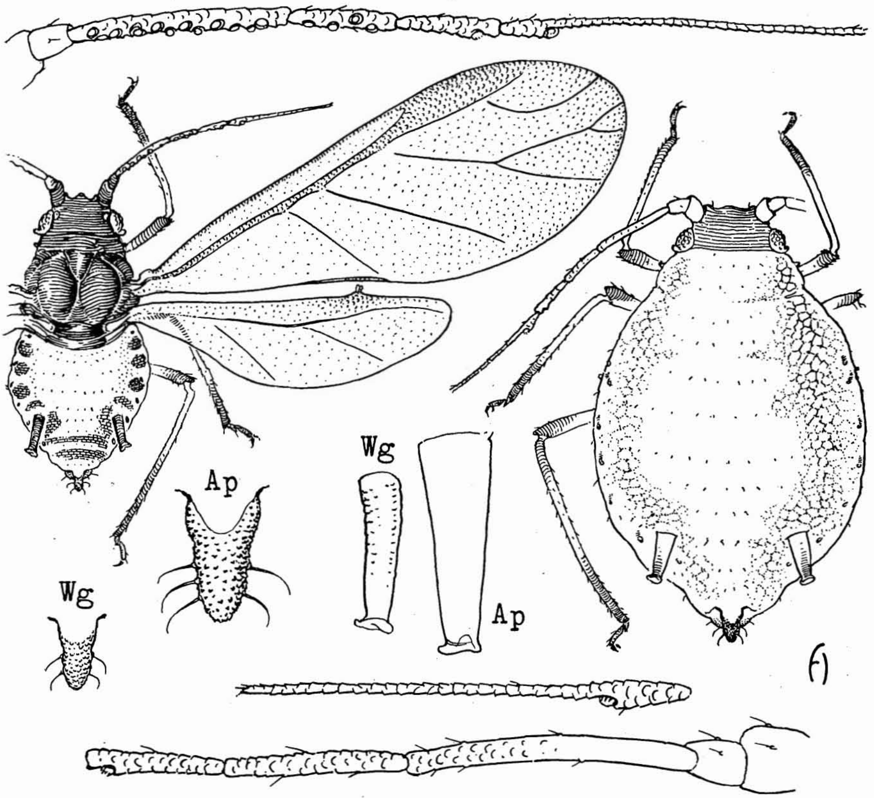


Figure 31—*Aphis avenae* Fabricius. The rice aphid. (Drawn by Abernathy.)

15(14). Cauda conspicuously constricted, with about two hairs on each side........................**bambusae** Fullaway.
Cauda indistinctly constricted, at least not so strongly as in *bambusae,* with about four hairs on each side...... ....**sacchari** Zehntner.

16(13). Cauda with only three hairs on each side; less than 2 mm. in length..............................**gossypii** Glover.
Cauda with four or more hairs on each side; length 2 mm. or more.........................**citricidus** (Kirkaldy).

17(12). Cornicles longer than third antennal segment.......... ....**medicaginis** Koch.
Cornicles shorter than third antennal segment...........18

18(17). Cornicles without imbricate sculpturing (fig. 38)...... ....**helichrysi** Kaltenbach.
Cornicles with imbricate sculpturing distinct............19

19(18). Third antennal segment with several distinct sensoria... ....**middletonii** Thomas.
Third antennal segment without sensoria...............20

20(19). Cauda with four or more hairs on each side...........
.................................**rumicis** Linnaeus.
Cauda with only two or three hairs on each side.........21

21(20). Third antennal segment longer than four plus five.....
...........................**ferruginea-striata** Essig.
Third antennal segment shorter than four plus five...
....................................**maidis** Fitch.

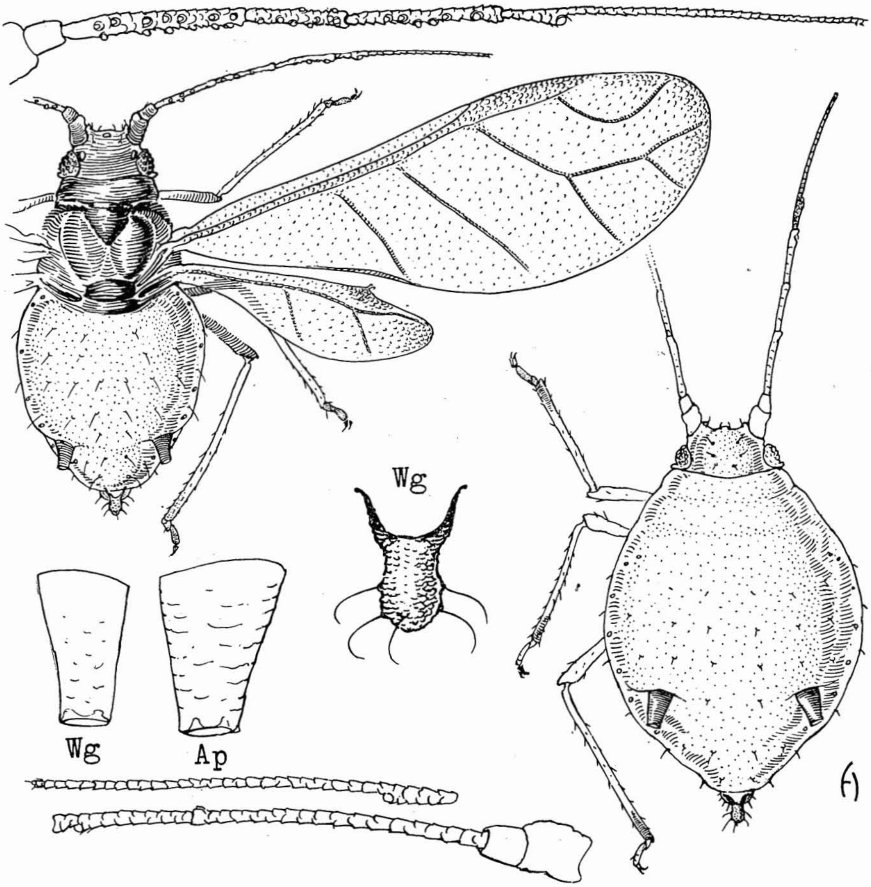


Figure 32—*Aphis bambusae* Fullaway. The bamboo aphid. (Drawn by Abernathy.)

Aphis avenae Fabricius (fig. 31).

Aphis avenae Fabricius, 1794:214.

Yamataphis oryzae Matsumura, Jour. College Agr. Tohoku Imperial Univ., Sapporo 7:413, 1917, pl. 16, fig. 6, a–c.

The rice aphid.

This species was first recorded from Hawaii by Timberlake in 1924 on the basis of a single example which proves to be *Cerosipha subterranea,* according to

C. E. Pemberton, who examined the material while reading this text. Hence, we have no record of this species in the Hawaiian Islands. However, I have retained the species in the text because it may yet be discovered here.

Hostplant: rice. It attacks the roots of the hostplant.

This species is considered a pest of rice in Japan. Because of an error in identification, it was recorded from roots of sugarcane in Honolulu, but the species involved was *Cerosipha subterranea,* which see.

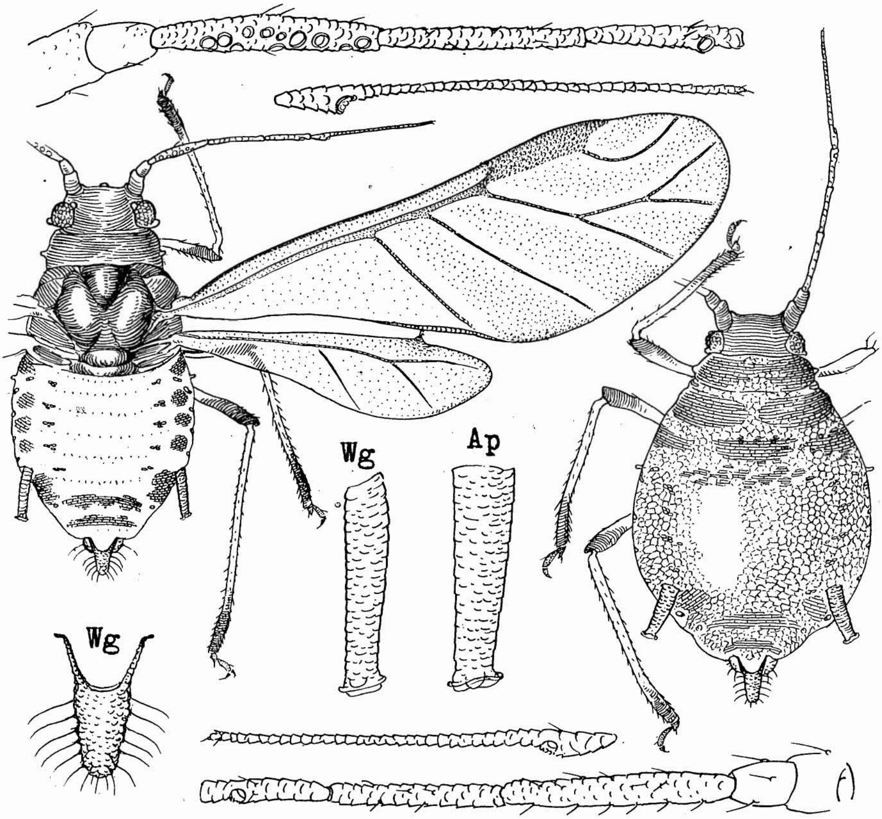


Figure 33—*Aphis citricidus* (Kirkaldy). The brown citrus aphid. (Drawn by Abernathy.)

Aphis bambusae Fullaway (fig. 32).

Aphis bambusae Fullaway, 1910:35, figs. 5, 6.

Melanaphis bambusae (Fullaway) Van der Goot, 1917:61, figs. 11, 11*a, b*.

The bamboo aphid.

Oahu (type locality: Honolulu).

Immigrant. Now known from Java, Malay Peninsula, China and Formosa.

Hostplants: bamboos (*Phyllostachys* ?, *Bambusa*).

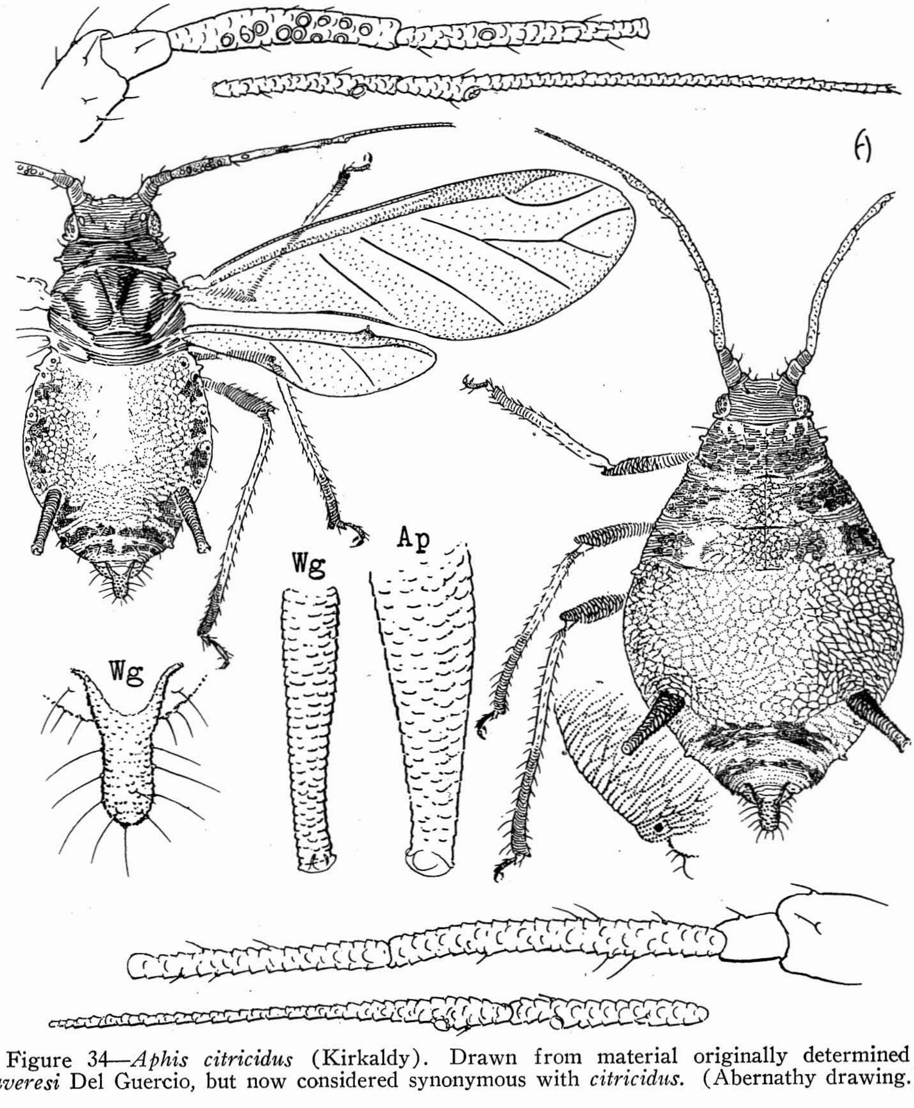


Figure 34—*Aphis citricidus* (Kirkaldy). Drawn from material originally determined as *taveresi* Del Guercio, but now considered synonymous with *citricidus*. (Abernathy drawing.)

The type material is in the collection of the Territorial Board of Agriculture and Forestry in Honolulu, but the type slide was not designated by Fullaway until recently—during the preparation of this text.

Aphis citricidus (Kirkaldy) (figs. 33, 34).

Myzus citricidus Kirkaldy, 1907:100.

Aphis citricola Van der Goot, Mitt. Naturhist. Mus. Hamburg 29:273, 1912 (I have not been able to see this reference).

Aphis tavaresi Del Guercio, 1916:217, pl. 2, figs. 22–27.

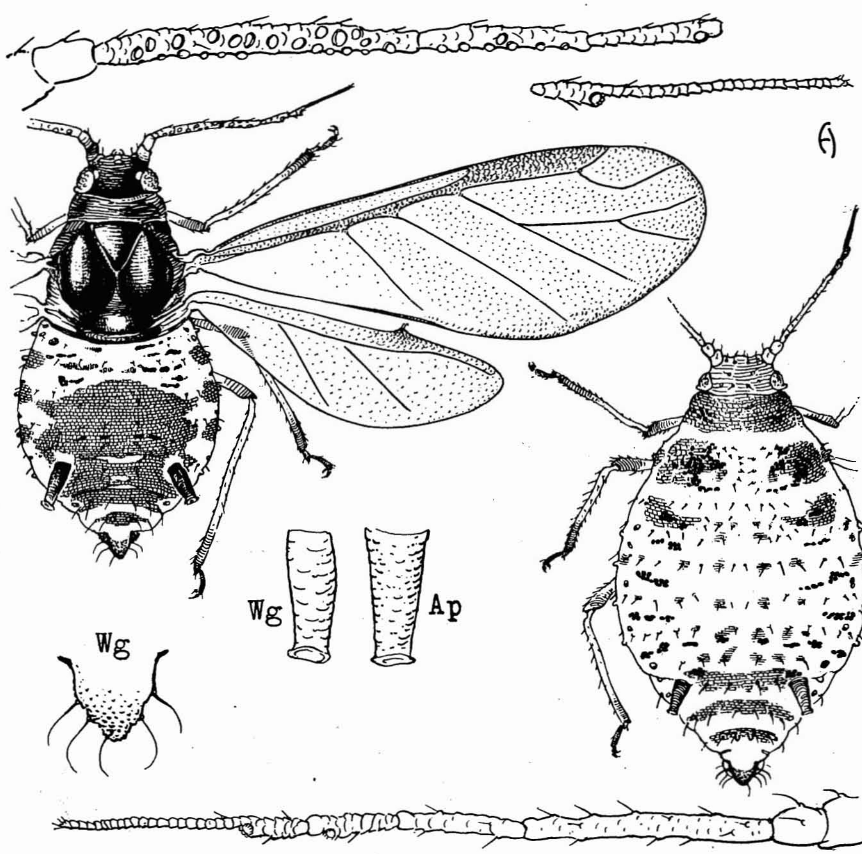


Figure 35—*Aphis ferruginea-striata* Essig. The rusty-banded aphid. (Drawn by Abernathy.)

The brown citrus aphid.

Kauai, Oahu (type locality not specifically designated), Hawaii, other islands (?).

Immigrant. Considered to be a Chinese species. I have collected it in Fiji. Also known from Japan and Africa.

Hostplants: *Azalea,* orange, pomelo.

Predators: *Chrysopa microphya* McLachlan, *Anomalochrysa rufescens* McLachlan (Neuroptera: Chrysopidae); *Zelus renardii* Kolenati (Heteroptera: Reduviidae); *Coccinella repanda* Thunberg, *Leis conformis* (Boisduval), *Cryptolaemus montrouzieri* Mulsant, *Platyomus lividigaster* Mulsant, *Scymnus notescens* Blackburn, *Bothrocalvia (Coelophora) pupillata* (Swartz), *Rhizobius ventralis* (Erichson) (Coleoptera: Coccinellidae); *Ischiodon scutellaris* (Fabricius) (Diptera: Syrphidae).

This species gets its common name from the fact that the young are brownish in color. The insects quickly cover young orange shoots, and the species was reported formerly to have caused much damage in Hawaii. Perhaps the types were never designated by Kirkaldy; in fact, they may not have been preserved.

Aphis ferruginea-striata Essig (fig. 35).

Aphis ferruginea-striata Essig, 1938:464, fig. 3.

The rusty-banded aphid.

Kauai, Oahu, Hawaii.

Immigrant. Described from California. First discovered in the Hawaiian Islands by me at Honolulu in 1942.

Hostplant: carrot.

Among plants attacked by this species in California and which may also be expected to be infested here are celery and parsley. The species characteristically feeds at the base of the plant or even on the subterranean parts. It is usually well protected by earthen "barns" built by the ant, *Pheidole megacephala*.

Aphis gossypii Glover (figs. 36, 37).

Aphis gossypii Glover, Rept. Comm. Agr. of the Operations of the Dept. for 1876, 1877:36 (I have not consulted this reference); 1855:62, pl. 3 (not named). Chittenden, 1906:1.

The cotton or melon aphid.

Kauai, Oahu, Molokai, Maui, Hawaii, French Frigate Shoal, Midway.

Immigrant. A nearly cosmopolitan species which was probably one of the early

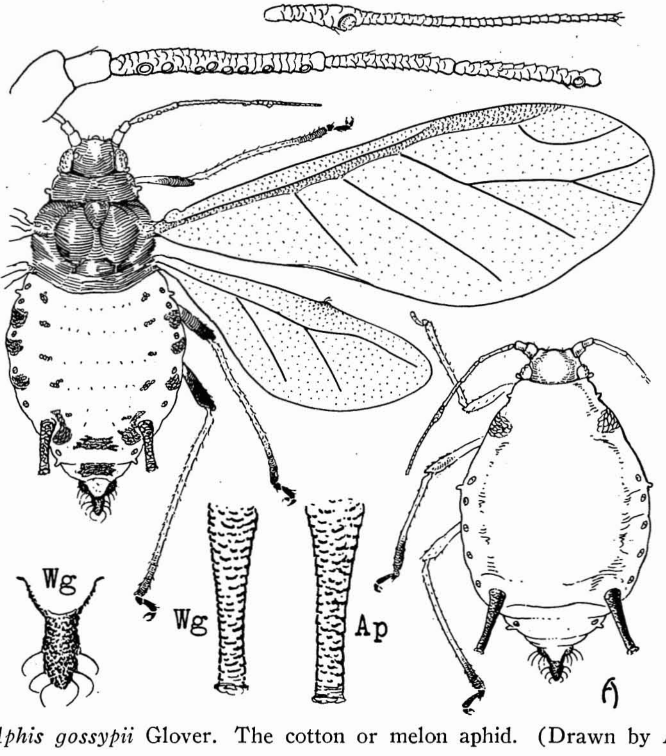


Figure 36—*Aphis gossypii* Glover. The cotton or melon aphid. (Drawn by Abernathy.)

aphis introductions to the islands, but I do not have any definite information as to when it was first discovered in Hawaii. It was first listed by name from the Hawaiian Islands by Fullaway in 1909 (pp. 9–10, fig. 3).

Hostplants: *Ageratum, Arctium lappa,* asparagus, avocado, *Azalea,* banana, beet, *Bidens pilosa, Brassica* ("shirona"), *Caladium bicolor, Cassia bicapsularis, Cassia nodosa, Cattleya* orchid, *Clerodendron, Commelina, Cordyline terminalis* ("ti"), cowpea, *Crotalaria incana, Crotalaria mucronata, Crotalaria saltiana,* cucumber, cultivated cotton, *Cuphea hyssopifolia, Desmodium uncinatum,* dryland taro, eggplant, *Erechtites valerianaefolia, Euphorbia piluliflora,* French marigold, garden bean, *Gnaphalium, Gossypium drynarioides, Gossypium tomentosum,* "grass," guava, *Hibiscadelphus hualalaiensis, Hibiscus rosa-sinensis, Hibiscus sabdariffa, Hibiscus tiliaceus,* hollyhock, *Indigofera anil, Ipomoea pentaphylla, Ixora, Lagerstroemia indica, Malva parviflora, Malvastrum coromandelianum,* marigold, Mexican creeper, *Mucuna,* okra, orchids, papaya, *Passiflora edulis, Phaseolus lunatus, Piper* ("kawa"), *Plumeria, Portulaca,* potato, *Senecio, Sida cordifolia, Sida rhombifolia, Solanum nodiflorum,* spinach, *Stachytarpheta dichotoma,* sunflower, sweet potato, taro, *Tecoma* (?), tomato, *Vinca rosea, Waltheria americana, Zinnia, Zingiber,* zucchini.

Parasites: *Aphelinus gossypii* Timberlake (Hymenoptera: Aphelinidae), *Lysiphlebus testaceipes* (Cresson) (Hymenoptera: Braconidae).

Predators: *Nesomicromus vagus* Perkins (Neuroptera: Hemerobiidae); *Zelus renardii* Kolenati (Heteroptera: Reduviidae); *Platyomus lividigaster* Mulsant, *Coelophora inaequalis* (Fabricius) (Coleoptera: Coccinellidae); *Allograpta obliqua* (Say) (Diptera: Syrphidae); *Leucopis nigricornis* Egger (Diptera: Ochthiphilidae).

This is perhaps our commonest and most destructive aphid. It is a minor pest of beans, potatoes, spinach, beets and other plants, but it is a major pest of cucumbers and okra. It is usually impossible to raise cucumbers here without the application of an insecticide (Bordeaux mixture has proved valuable), because of the devastating attacks of this aphid. It is a vector of cucumber mosaic. Heavy infestation causes a drying and wrinkling of the leaves of some hostplants. It is occasionally a nuisance on orchids.

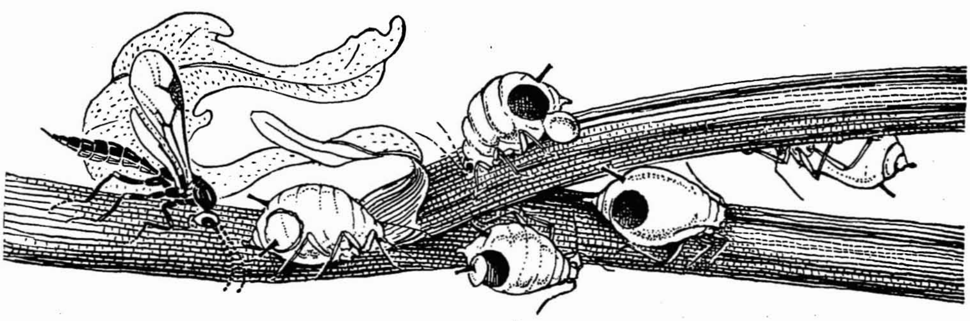


Figure 37—*Aphis gossypii* Glover, parasitized by the braconid wasp *Lysiphlebus testacipes* (Cresson) (left) and showing aphid "mummies" with exit holes made by the emerging wasps. (Drawn by Abernathy.)

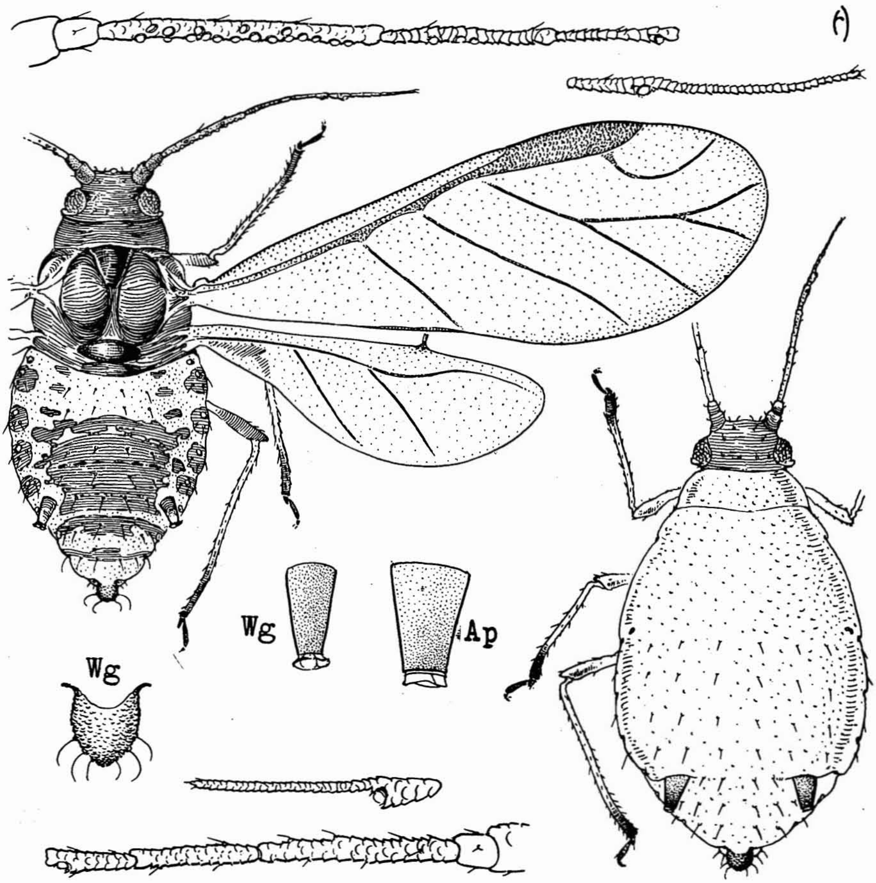


Figure 38—*Aphis helichrysi* Kaltenbach. The leaf curl plum aphid. (Drawn by Abernathy.)

Aphis helichrysi Kaltenbach (fig. 38).

Aphis helichrysi Kaltenbach, 1843:102.

Aphis myosotidis Koch, 1854:57, figs. 72, 73. Fullaway, 1910:42.

Anuraphis helichrysi (Koch), Timberlake, 1924:451.

The leaf curl plum aphid.

Kauai, Oahu, Maui, Hawaii.

Immigrant. A widespread species first reported from the Hawaiian Islands by Fullaway (1910:42) from specimens collected on Mount Tantalus, Honolulu.

Hostplants: *Ageratum conyzoides, Erechtites, Erigeron, Gnaphalium purpureum.*

Aphis maidis Fitch (figs. 39, 40, 41).

Aphis maidis Fitch, Second Rept. Noxious and Beneficial Insects of New York, p. 318, 1856 (I have not checked this reference).

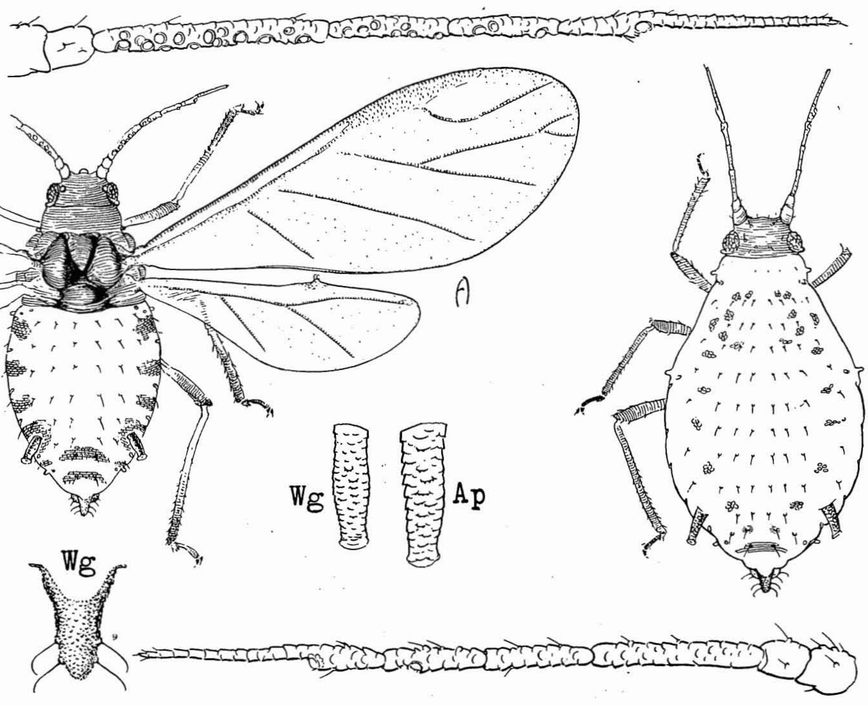


Figure 39—*Aphis maidis* Fitch. The corn-leaf aphid. (Drawn by Abernathy.)

The corn-leaf aphid.

Kauai, Oahu, Molokai, Hawaii.

Immigrant. A nearly cosmopolitan species first recorded from the Hawaiian Islands by Fullaway (1910:41) from specimens collected at Honolulu and Kunia, Oahu.

Hostplants: *Andropogon,* asparagus, barley, Bermuda grass, *Cenchrus hillebrandianus, Chaetochloa lutescens, Chloris radiata, Chloris paraguayensis,* corn, *Dactyloctenium aegypticum,* dwarf evergreen broom corn, *Echinochloa colonum, Echinochloa crusgalli, Eleusine indica* (goose grass), *Eragrostis cilianensis,* garden bean, *Heteropogon contortus* (pili grass), Job's tears (*Coix lacryma-jobi*), Johnson grass, oats, *Oxalis, Panicum barbinode, Panicum dichotomiflorum, Panicum maximum, Panicum sanguinale, Panicum torridum,* papaya, *Paspalum fimbriatum, Paspalum orbiculare,* pearl millet, *Pennisetum glaucum, Polygonum pennsylvanicum,* potato, rice, *Scirpus maritimus, Setaria glauca, Sorghum* (*Holcus sorghum*), Sudan grass (*Holcus sudanensis*), sugarcane, summer squash, *Syntherisma chinensis, Syntherisma sanguinalis, Syntherisma pruriens,* tomato, *Tricholaena rosea* (redtop), *Tripsacum laxum,* Tunis grass, *Valota insularis,* wheat.

Parasites: *Aphelinus maidis* Timberlake (Hymenoptera: Aphelinidae), *Lysiphlebus testaceipes* (Cresson) (Hymenoptera: Braconidae); unidentified fungi.

Predators: *Tenodera angustipennis* Saussure (Orthoptera: Mantidae); *Chrysopa lanata* Banks (Neuroptera: Chrysopidae); *Eumicromus navigatorum* (Brauer) (Neuroptera: Hemerobiidae); *Coelophora inaequalis* (Fabricius) (Coleoptera: Coccinellidae); *Allograpta obliqua* (Say) (Diptera: Syrphidae); unidentified mites.

Kunkel (1922:58–64) investigated the transmission of yellow stripe or mosaic disease of sugarcane and confirmed the conclusions of other workers that this aphid could transmit the disease from corn and other plants to sugarcane. He found that in Hawaii the aphid does not maintain itself or reproduce on sugarcane, but that it does feed upon cane and will invade a cane field if its usual hosts near by are weeded out or dry up. Some later information seems to indicate that the species may rarely establish small colonies on young cane shoots, however. Mosaic was reported at the time of Kunkel's investigations to attack sugarcane, sorghum, corn, Sudan grass, goose grass and *Andropogon*. Kunkel concludes that: "All crops that harbor the corn aphid and all grasses subject to mosaic disease should be grown at some distance from sugarcane fields. Keeping fields free from weeds and wild grasses is to be recommended, not only because this is good agricultural practice, but because it will help to prevent the spread of the Yellow Stripe disease" (p. 64).

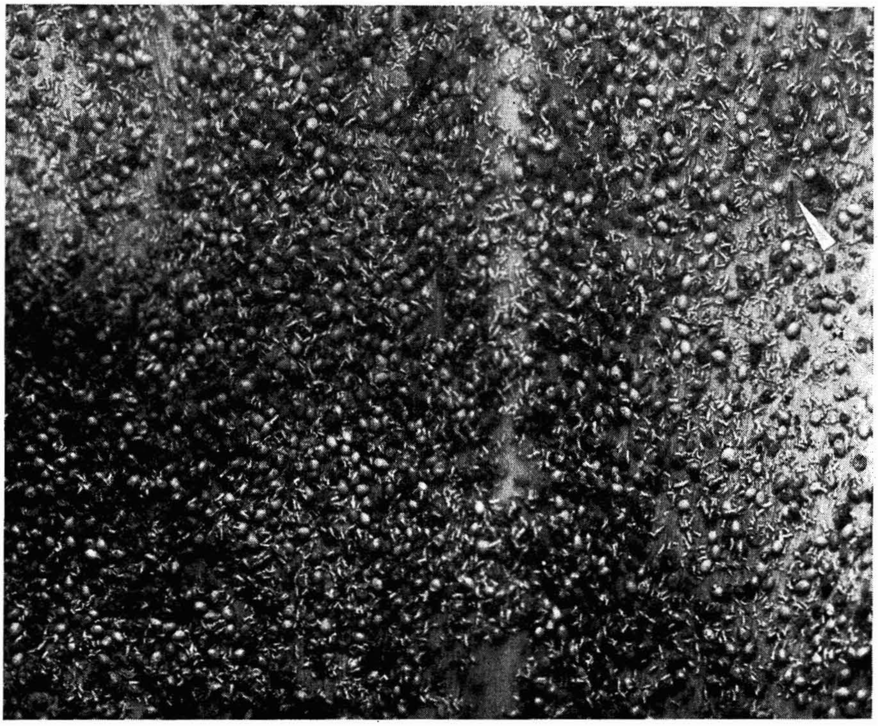


Figure 40—*Aphis maidis* Fitch. A heavy infestation of corn aphid on a corn leaf showing high parasitism by *Lysiphlebus testaceipes* (Cresson). Arrow points to an adult aphid near upper right corner.

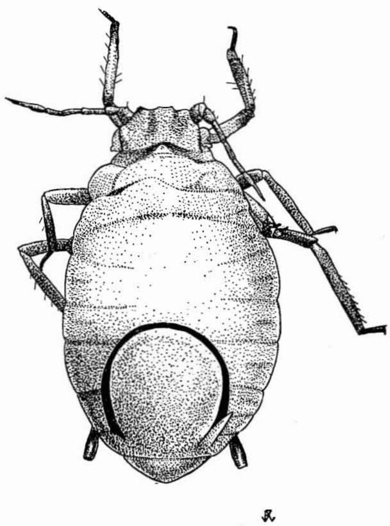


Figure 41—*Aphis maidis* Fitch. The corn-leaf aphid. A "mummy" of an apterous individual killed by the braconid wasp parasite *Lysiphlebus testaceipes* (Cresson), showing the lid-like cap on the emergence hole in the abdomen. (After Williams, 1931.)

Hadden (1928:130–142) also studied this species in relation to sugarcane mosaic. He noted (p. 133) that:

> Ten days after an aphis is born it begins to reproduce, and it may produce from one to two young every day for twenty days. In the meantime the second generation begins to reproduce, and by the end of thirty days the third generation are reproducing; so in a very short time the number of descendants from one aphis is enormous. In two months the offspring of one aphis would be over 1,000,000, provided conditions were suitable and that each aphis lived thirty days. However, this rapidity of reproduction is only approached upon sorghum, corn, and Sudan grass, never on any of the other grasses.

Aphis medicaginis Koch (fig. 42).
Aphis medicaginis Koch, 1854:94, figs. 125–126.

The cowpea or bean aphid.

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. Almost cosmopolitan. Apparently the first record of this species in the Hawaiian Islands is that by Fullaway (1910:39, footnote), who found what was taken to be possibly this species in 1909 or earlier on Oahu. Perhaps the species recorded as *Aphis papaveris* by Silvestri in 1909 (*Bollettino Quindicinale Soc. Agricoltori Italiani* 14:344) also refers to this aphid, but see the note under *Aphis rumicis*.

Hostplants: *Acacia farnesiana*, alfalfa, asparagus, cowpea, *Crotalaria, Datura stramonium, Deschampsia, Dolichos lablab, Erechtites valerianaefolia, Euphorbia pilulifera,* garden bean, *Indigofera anil, Indigofera suffruticosa,* lima bean, *Medicago denticulata, Mirabilis jalapa,* night-blooming cereus (*Cereus triangularis*),

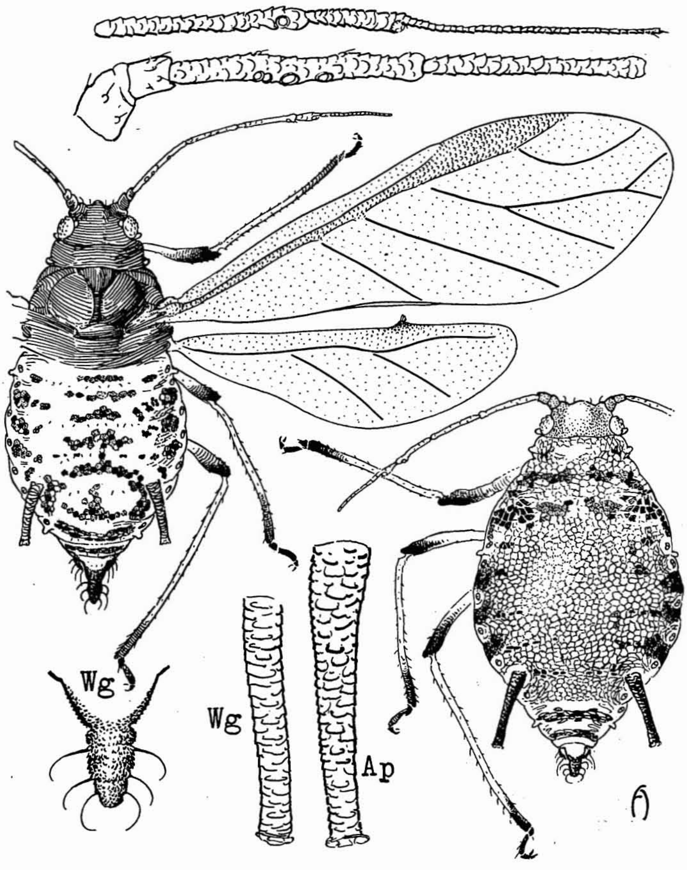


Figure 42—*Aphis medicaginis* Koch. The cowpea or bean aphid. (Drawn by Abernathy.)

papaya, pigeon pea, *Portulaca,* potato, sweet potato, tomato, *Tribulus, Tribulus cistoides, Vigna marina.*

Parasites: *Lysiphlebus testaceipes* (Cresson) (Hymenoptera: Braconidae); *Aphelinus gossypii* Timberlake (Hymenoptera: Aphelinidae).

This species is a major pest of various beans in Hawaii, especially those of the cowpea group.

The adults are shiny black, while the nymphs are dull grayish in color. Large colonies often infest the leaves, stems and pods of plants of all ages and cause the plants to wither and die. This aphid is an important economic pest of a number of legumes, and it is at times abundant also on *Portulaca oleracea* and other weeds from which it often migrates to young bean plants.... It is seldom abundant on non-legume crops... (Holdaway and Look, *Proc. Hawaiian Ent. Soc.* 11(2):253, 1942).

Aphis middletonii Thomas (figs. 43, 44).

Aphis middletonii Thomas, Eighth Rept. State Entomologist, Illinois, p. 99, 1879 (I have not checked this reference).

Aphis swezeyi Fullaway, 1910:36, figs. 7, 8. New synonym.

The erigeron-root aphid (aster-root aphid).

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. This widespread species was not recorded under its proper name in our literature until Timberlake's record in 1920 (*Proc. Hawaiian Ent. Soc.* 4(2):438). However, it was known to entomologists in Honolulu at least as early as 1909.

Hostplants: *Bidens pilosa, Callistephus chinensis* (Chinese aster), *Coreopsis, Eleusine indica, Emilia flammea, Emilia sonchifolia, Galinsoga parviflora, Gnaphalium,* papaya, *Portulaca, Solanum nodiflorum, Sonchus oleraceus,* tomato.

Parasite: *Lysiphlebus testaceipes* (Cresson) (Hymenoptera: Braconidae).

This is a root-inhabiting species which on occasion causes considerable plant damage, especially to asters, but it also occurs near the bases of the plants and on the foliage of some kinds.

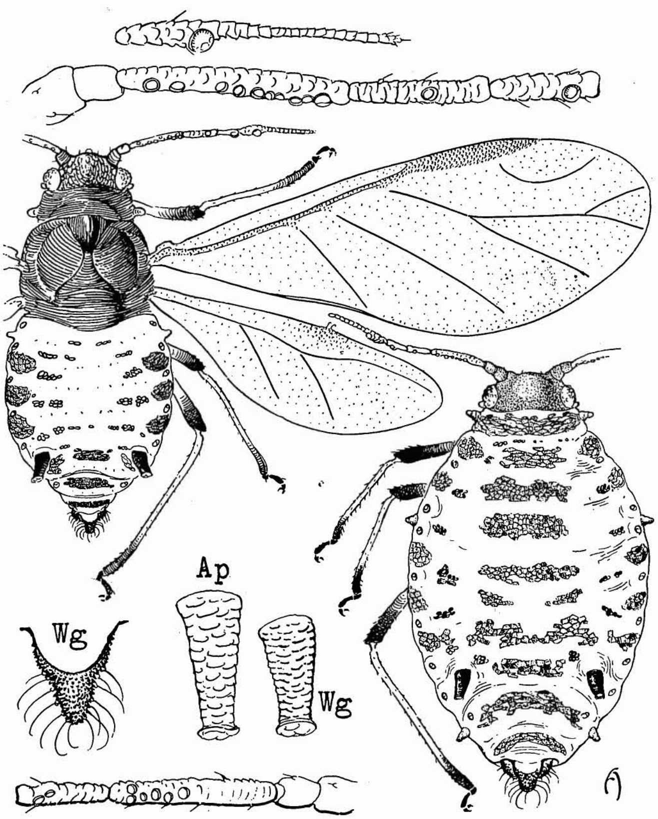


Figure 43—*Aphis middletonii* Thomas. The erigeron-root aphid. (Drawn by Abernathy.)

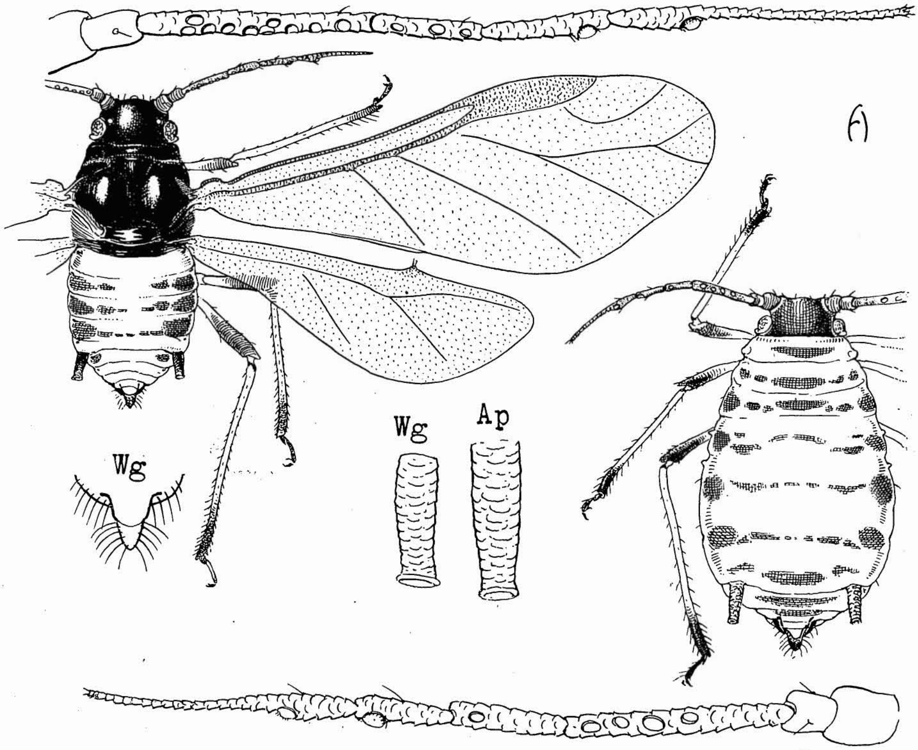


Figure 44—*Aphis middletonii* Thomas, drawn for comparison with figure 43 to show variation. This material was originally called *Aphis swezeyi* Fullaway. (Drawn by Abernathy.)

It is normally yellowish green or dark olive-green, often with a frosty or pulverulent covering. This pulverulence is usually arranged like a network consisting of small 5-sided figures or reticulations. Mounted specimens rarely reveal these as fine lines on the exoskeleton; if stained, however, they show the network well. They are characteristic of the species and aid in its identification. (Essig, 1938:473.)

Aphis swezeyi Fullaway has long been a puzzle in our fauna, but it appears that it is a synonym of *middletonii*. Essig concurs in this opinion.

Aphis rumicis Linnaeus (figs. 45, 46).
Aphis rumicis Linnaeus, 1758:451.

The dock aphid (bean aphid).
Kauai, Oahu, Hawaii.
Immigrant. A widespread species. Although not recorded in Hawaiian literature until 1944 by Look and McAfee (*Proc. Hawaiian Ent. Soc.* 12(1):108), this species was known in Honolulu some years previously (I have seen specimens

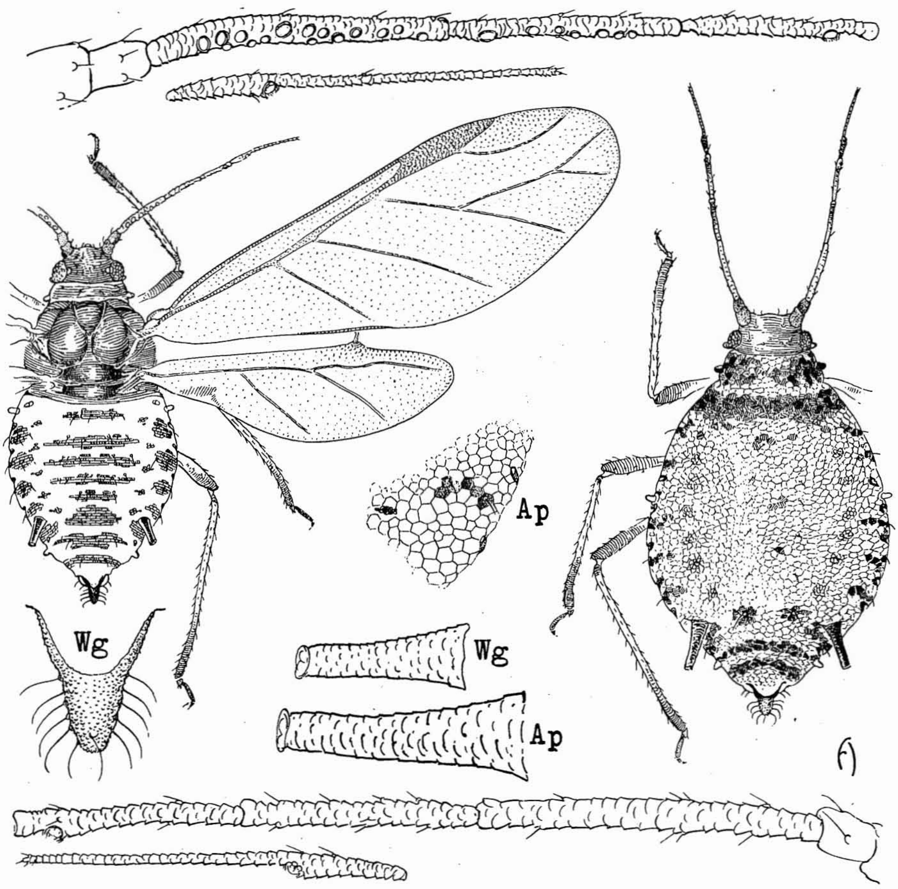


Figure 45—*Aphis rumicis* Linnaeus. The dock aphid. (Drawn by Abernathy.)

collected and identified by Pemberton in 1939), and it may have been confused earlier with other species of *Aphis*. There is also the possibility that this species may be the one recorded as *Aphis papaveris* by Silvestri in 1909 (see note under *medicaginus*).

Hostplants: *Arctium lappa, Bougainvillea spectabilis,* chili pepper, lima bean, *Nothopanax guilfoylei, Erechtites valerianaefolia* (fireweed), *Phaius grandifolius, Tithonia diversifolia.*

This species is known elsewhere as a vector of several plant diseases, and we can expect to find it on other hosts in Hawaii. Margaret Jones (1942:5–20) has published a detailed study of the species as it occurs in England.

It is a dark, greenish-black species, the apterous forms of which usually have rows of white spots of wax on the abdominal dorsum.

Figure 46—Deformation of *Nothopanax* by *Aphis rumicis* Linnaeus.

Aphis sacchari Zehntner (figs. 47, 48, 49).

Aphis sacchari Zehntner, 1897:551.

Longiunguis sacchari (Zehntner), of authors.

Aphis miscanthi Takahashi, 1921:55, pl. 9, 1, figs. 17–19 (type from Formosa).

The sugarcane aphid.

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. An Australasian species described from Java and which has become widespread on sugarcane. Although not reported by this name in Hawaiian literature until Kirkaldy's 1906 record (1907:99), it has long been known as a pest of sugarcane in the islands. Koebele noted its presence, as "Aphis, Sp.," on Kauai in 1896 (*Hawaiian Planters' Monthly*, 15:596, 1896).

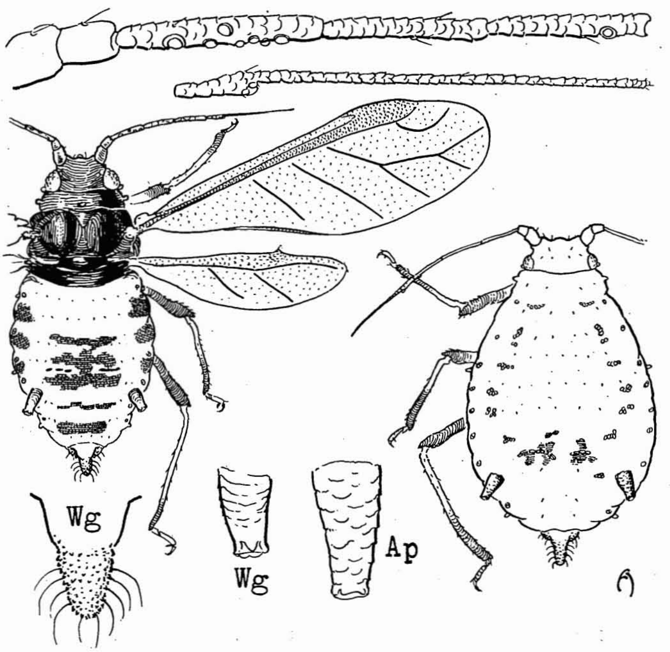


Figure 47—*Aphis sacchari* Zehntner. The sugarcane aphid. (Drawn by Abernathy.)

Hostplants: sugarcane, sorghum, corn, garden bean, pole bean, sweet potato, tomato, *Sonchus oleraceus*. Perhaps all these plants except sugarcane serve only as occasional hosts, and it is probable that the aphid does not reproduce on all of them.

Parasites: *Aphelinus maidis* Timberlake, *Prospaltella transvena* Timberlake (Hymenoptera: Aphelinidae); *Lysiphlebus testaceipes* (Cresson) (Hymenoptera: Braconidae).

Predators: *Nesomicromus vagus* Perkins (Neuroptera: Hemerobiidae); *Chrysopa lanata* Banks, *Chrysopa microphya* McLachlan (Neuroptera: Chrysopidae); *Coelophora inaequalis* (Fabricius), *Coccinella repanda* Thunberg, *Olla abdominalis* (Say), *Platyomus lividigaster* Mulsant, *Scymnus notescens* Blackburn, *Scymnus loewii* Mulsant (*vividus* Sharp) (Coleoptera: Coccinellidae); *Phaenobremia meridionalis* (Felt) (Diptera: Cecidomyiidae); *Leucopis nigricornis* Eggers (Diptera: Ochthiphilidae); *Ischiodon scutellaris* (Fabricius), *Allograpta obliqua* (Say) (Diptera: Syrphidae).

Although this species may build up in numbers locally, it is now considered a pest of minor importance, and it is kept well under control by parasites and predators. Individuals parasitized by the aphelinids turn dark in color and are easily distinguished from the pale unparasitized individuals. The attack of the braconid causes a swelling of the parasitized individual resulting in a pale brown "mummy."

Williams (1931:105–106) gives the following information on the species: it

...is usually of a dirty yellowish white color; sometimes brown or green-tinged individuals are common while winged females are still darker. It often occurs in considerable colonies on the underside of the lower leaves of young cane plants. Such infestations may assume tolerably large proportions, the affected leaves becoming spotted with rusty brown from beak-punctures, or quite drying up, while the copious honey-dew exuded from the end of the aphid's body, and dropping on the leaves below, furnishes an excellent medium for the growth of fungus, spores of which float everywhere on the air, and hence there results a sticky and smutty condition of the cane that is mildly comparable to an old-time leafhopper attack. The cane through loss of sap and perhaps because of interference with transpiration, receives a setback from which, however, it almost invariably recovers. While attacking sugar cane in general this aphid may show a partiality to a single variety and more than once we have found it heavily infesting U D 1, while the varieties alongside remained almost free from attack.... *A. sacchari* frequently appears on cane when the latter is but a few inches tall and, while sometimes frequenting the throat or spindle of the plant, usually selects the underside of the older, more or less horizontal leaves where its delicate body will not be exposed to the rays of a torrid sun. Migrating as winged females to such plants, young are soon brought forth alive (viviparously); they gather on the cane leaves in small groups that, granting favorable weather—preferably warm and dry—as well as the absence of enemies or the tardy arrival of these upon the scene, so increase in number as to form large patches or even to completely cover the lower surface of the leaves. Years ago this aphid was probably more abundant, because then it did not have so many introduced enemies.

Kunkel (1922:58) failed in attempts to obtain transmission of sugarcane mosaic by this species.

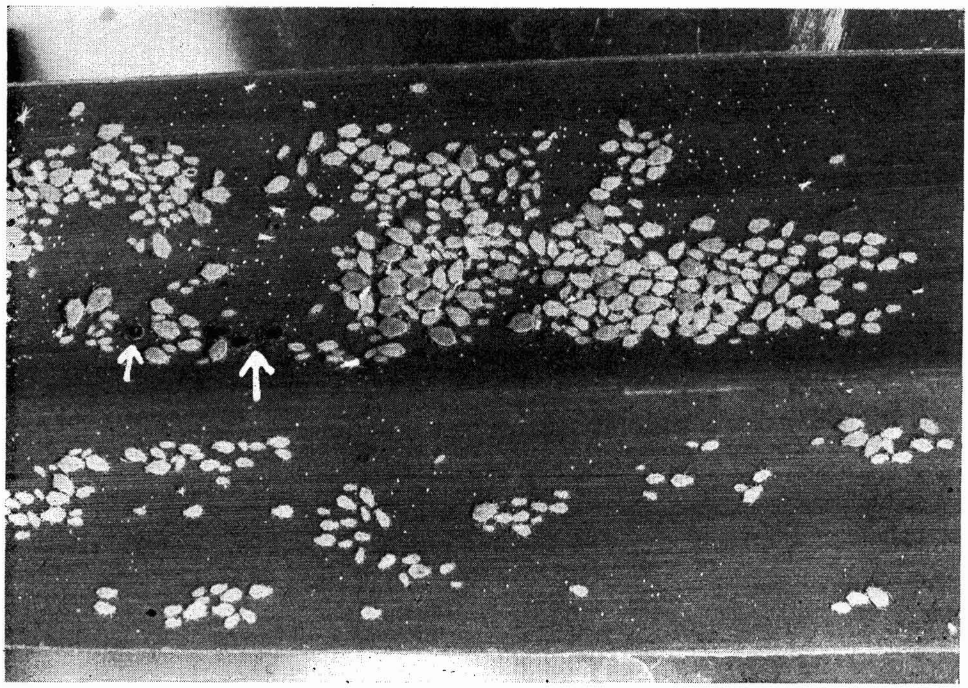


Figure 48—*Aphis sacchari* Zehntner, the sugarcane aphid, on a sugarcane leaf. Note the black, parasitized individuals.

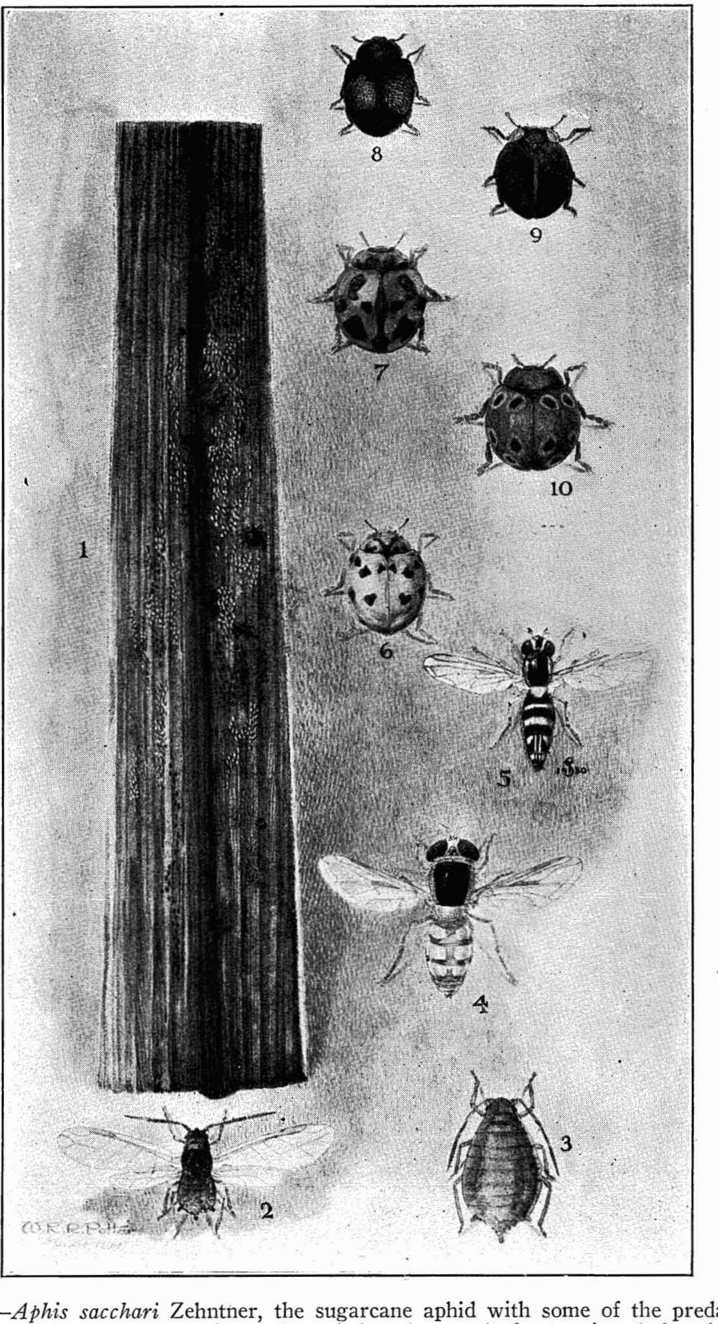


Figure 49—*Aphis sacchari* Zehntner, the sugarcane aphid with some of the predators introduced to control it. 1, undersurface of an infested cane leaf; 2, winged female aphid; 3, wingless female; 4, *Ischiodon scutellaris* (Fabricius); 5, *Allograpta obliqua* (Say); 6, *Olla abdominalis* (Say); 7, *Coelophora inaequalis* (Fabricius); 8, *Scymnus notescens* Blackburn; 9, *Platyomus lividigaster* Mulsant; 10, *Bothrocalvia* (*Coelophora*) *pupillata* (Swartz). (From a painting by W. R. Potter in the Experiment Station, H.S.P.A.; after Swezey, *Hawaiian Planters' Record* 13:194, 1915.)

Genus **BRACHYCOLUS** Buckton, 1879

Antennae six-segmented in alates and apterae, the prominent sensoria are circular or subcircular, frontal tubercles are wanting, the cornicles are reduced to small tuberculiform appendages which are shorter than the tapering cauda, the anal plate is rounded, M is forked twice in the fore wings, M and Cu are present in the hind wings, and the body setae are not particularly developed. The genus resembles *Brevicoryne* closely, but the cornicles are more reduced.

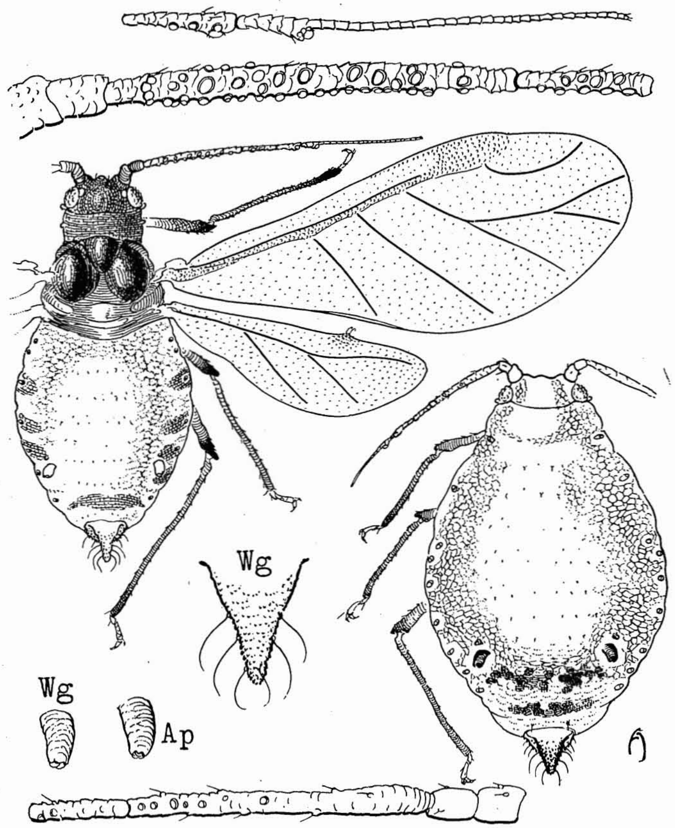


Figure 50—*Brachycolus heraclei* Takahashi. The celery aphid. (Abernathy drawing.)

Brachycolus heraclei Takahashi (fig. 50).
Brachycolus heraclei Takahashi, 1921:60.

The celery aphid.
Oahu, Maui, Hawaii.

Immigrant. Originally described from Formosa. First found in the Hawaiian Islands by Holdaway at Waialua, Oahu, in 1940.

Hostplant: celery, upon which it is becoming a pest in Hawaii. It may be controlled with nicotine sulphate.

Genus **BREVICORYNE** Van der Goot, 1915

Antennae six-segmented in alates and apterae, the sensoria prominent, round or subcircular, frontal tubercles low and poorly developed, cornicles short, about as long as the conical cauda, but longer than broad, anal plate rounded, fore wings with M forked twice, M and Cu present in the hind wings, body setae pointed and not prominent. This group is not much different from *Brachycolus* or *Rhopalosiphum*.

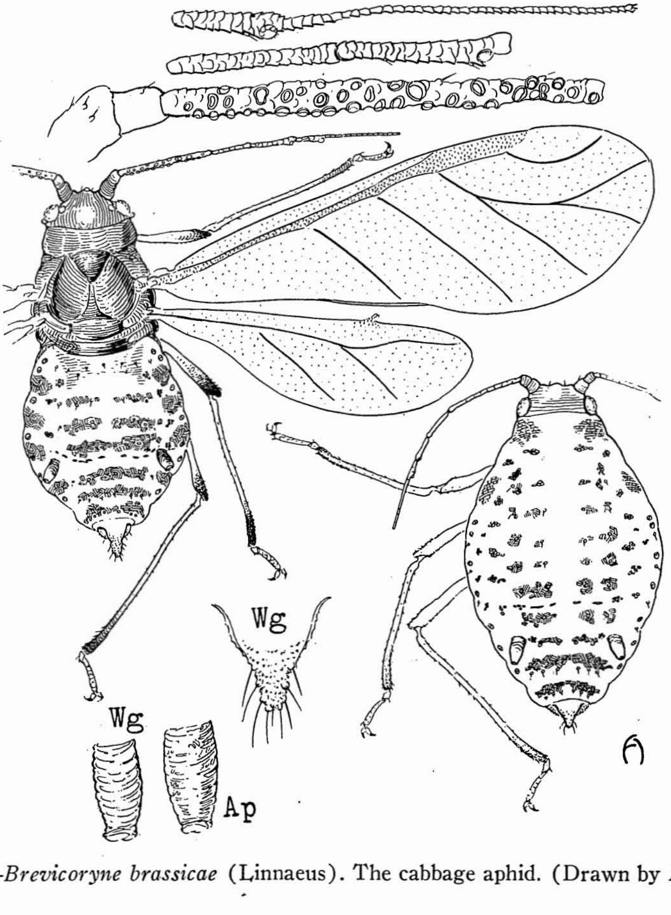


Figure 51—*Brevicoryne brassicae* (Linnaeus). The cabbage aphid. (Drawn by Abernathy.)

Brevicoryne brassicae (Linnaeus) (fig. 51).

Aphis brassicae Linnaeus, 1758:452.

Loxerates brassicae (Linnaeus), of authors.

The cabbage aphid.

Oahu, Hawaii.

Immigrant. Cosmopolitan. The first record of the occurrence of this species in Hawaii appears to be that by Kirkaldy in 1907 (*Proc. Hawaiian Ent. Soc.* 1(5):206, 1908).

Hostplants: broccoli, cabbage, *Capparis sandwichiana,* carrot, cauliflower, celery, daikon, kale.

Parasite: *Diaretus chenopodiaphidis* Ashmead, formerly misidentified in Hawaii as *Diaretus rapae* (Curtis), (Hymenoptera: Braconidae).

This insect is a pest of crucifers and has caused local damage to celery. It may be controlled by the use of nicotine sulphate spray or nicotine dust.

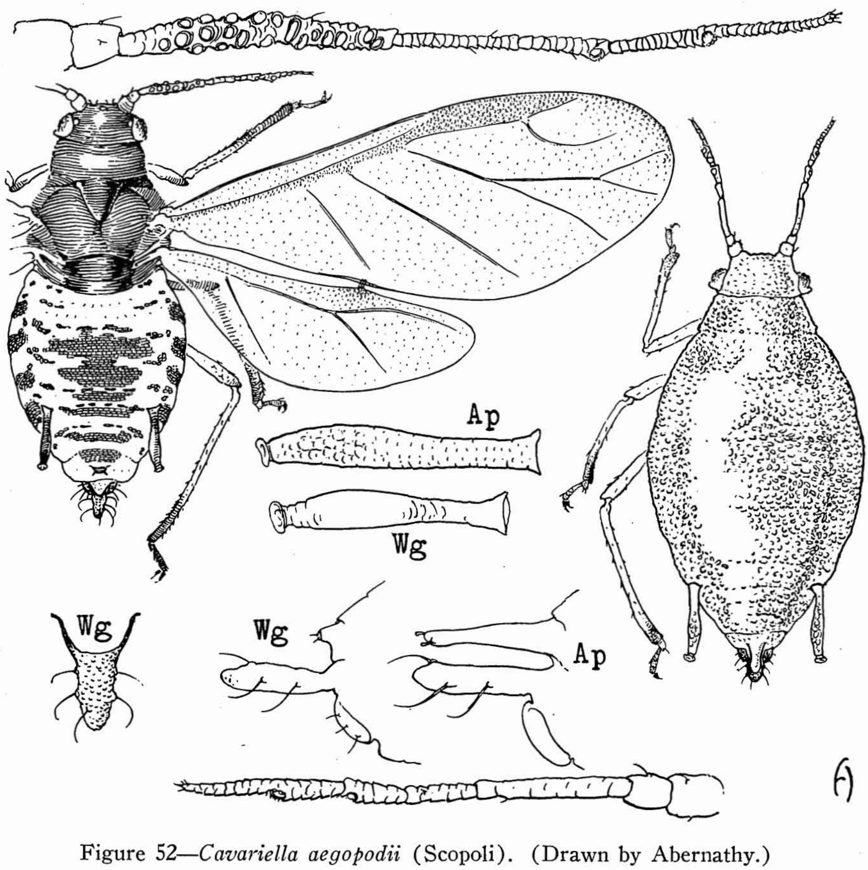


Figure 52—*Cavariella aegopodii* (Scopoli). (Drawn by Abernathy.)

Genus **CAVARIELLA** Del Guercio, 1911

Antennae six-segmented in alatae and apterae, sensoria prominent, subcircular, antennal tubercles obsolete, cornicles elongate, longer than the cauda, with a distinct, horn-like protuberance above the cauda, anal plate rounded, fore wings with two forks from M, M and Cu present in hind wings, body setae pointed and not conspicuous.

The cauda-like projection above the cauda is best seen from the side and is more elongated in the apterae, and this character will serve to separate the genus from all other Hawaiian aphids.

Cavariella aegopodii (Scopoli) (fig. 52).

Aphis aegopodii Scopoli, Entomologica Carniolica, p. 399, 1763 (I have not seen this reference).

Hawaii.

Immigrant. Widespread from Europe. First found at Kohala, Hawaii, by Marvin in 1939.

Hostplants: carrot, celery, *Fagara dipetala geminicarpa*.

No other aphid in the Hawaiian Islands has such a supra-caudal protuberance, and thus it may be identified easily. It has been listed in local literature as *Cavariella capreae* (Fabricius).

Genus **CEROSIPHA** Del Guercio, 1900

Antennae five-segmented in both apterae and alates, sensoria circular; frontal tubercles ill-defined; cornicles longer than the cauda, cylindrical; cauda subcylindrical or slightly constricted; anal plate rounded; fore wings with two forks to M, M and Cu present in hind wings; body hairs well developed, pointed.

The five-segmented antennae in both the winged and adult apterous forms will serve to distinguish the genus from rather similar-appearing aphids in Hawaii.

Cerosipha subterranea (Mason) (fig. 53).

Rhopalosiphum subterraneum Mason, 1937:166, fig. 1.

Cerosipha californica Essig, 1944:177, fig. 1.

The rice-root aphid.

Oahu.

Immigrant. Widespread across the southern United States and the West Indies. First discovered in Hawaii in 1924 by Timberlake, who took it in Honolulu (misidentified as *Aphis avenae,* which see).

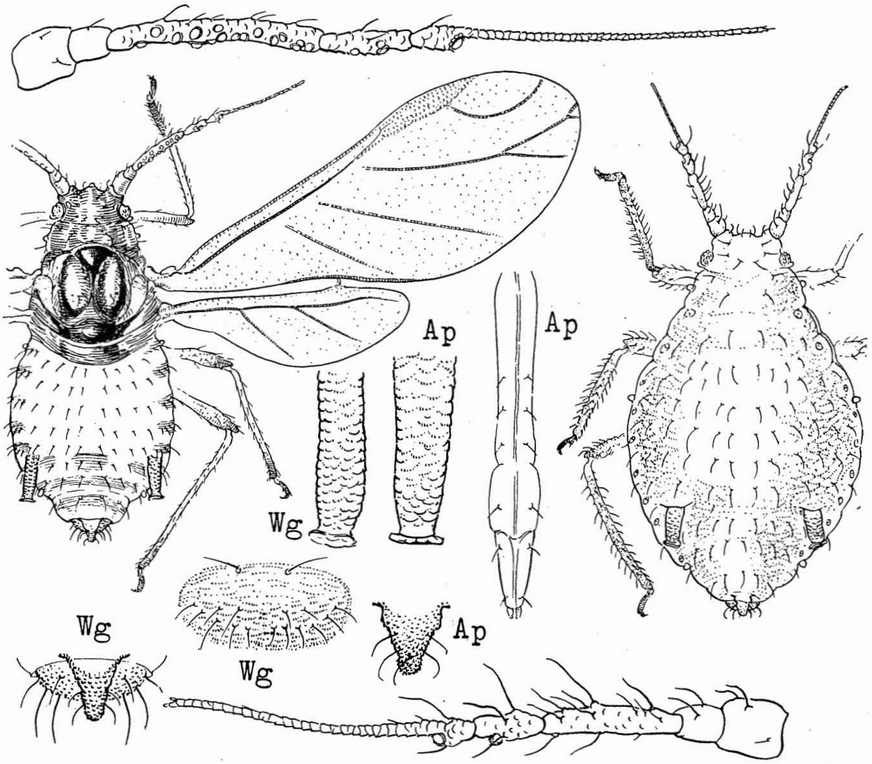


Figure 53—*Cerosipha subterranea* (Mason). The rice-root aphid. (Drawn by Abernathy, and furnished for this text through the kindness of E. O. Essig and the Division of Entomology, University of California.)

Hostplants: rice, sugarcane, tomato (elsewhere it has been found at the roots of cotton, okra, celery, iris, grass, *Gnaphalium,* etc.—plants which we may expect to find infested in Hawaii in the future). C. E. Pemberton found it on the roots of rice at Waipio, Oahu, and on the roots of sugarcane growing in a water culture at Honolulu in 1939.

Genus **RHOPALOSIPHUM** Koch, 1854

Antennae six-segmented in alates and apterae, sensoria prominent and circular; frontal tubercles ill-defined; cornicles elongate, longer than the tapering or constricted cauda, swollen and usually somewhat clavate; anal plate rounded; fore wings with M twice-forked, hind wings with M and Cu present; body setae short and inconspicuous in our species.

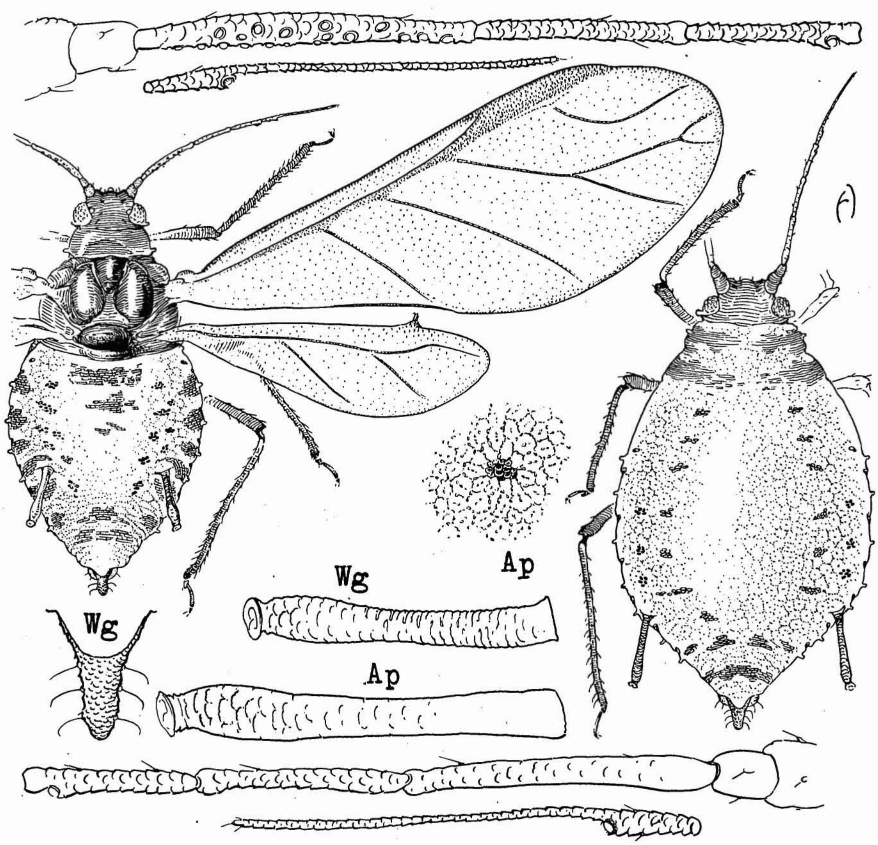


Figure 54—*Rhopalosiphum nymphaeae* (Linnaeus), the water-lily aphid. (Drawn by Abernathy.)

Key to the Species of Rhopalosiphum Found in Hawaii

1. Cornicles twice as long as cauda or longer, obviously clavate, constricted basal part faintly wrinkled, swollen part smooth .... **nymphaeae** (Linnaeus).
   Cornicles less than twice as long as cauda, not strongly constricted in basal half and thus not distinctly clavate as in *nymphaeae* 2
2. Terminal filament of sixth antennal segment four or more times as long as base; on grasses......... **prunifoliae** (Fitch).
   Terminal filament of sixth antennal segment not over three times as long as base; commonly on crucifers........... .... **pseudobrassicae** (Davis).

Rhopalosiphum nymphaeae (Linnaeus) (fig. 54).
Aphis Nymphaeae Linnaeus, 1761:260.

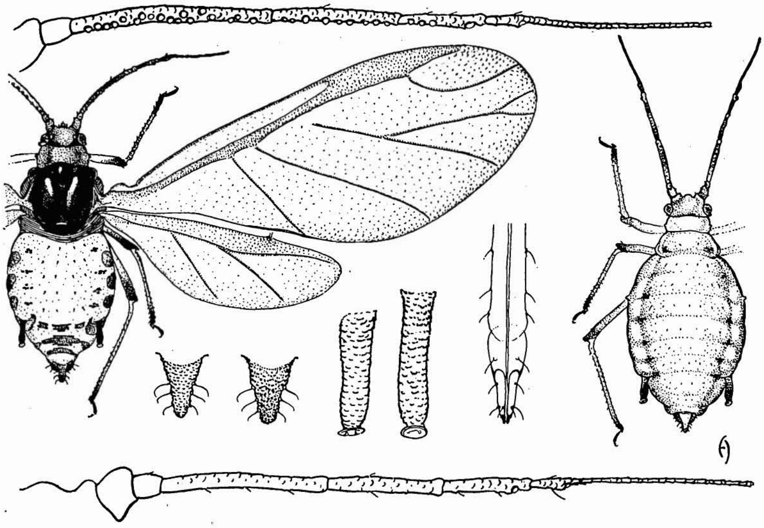


Figure 55—*Rhopalosiphum prunifoliae* (Fitch). (Drawn by Abernathy for this text through the courtesy of E. O. Essig and the Division of Entomology, University of California.)

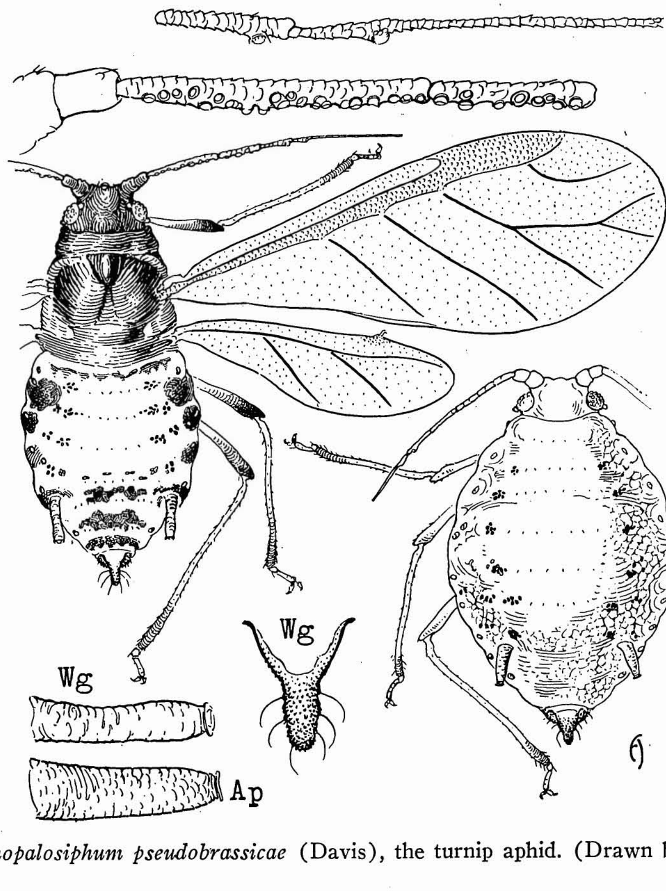


Figure 56—*Rhopalosiphum pseudobrassicae* (Davis), the turnip aphid. (Drawn by Abernathy.)

The water-lily aphid.

Kauai, Oahu, Maui, Hawaii.

Immigrant. This widespread species evidently has long been confused with *Aphis gossypii* in Hawaii, and it was not recorded in our literature under its proper name until Fullaway noted its presence in 1938 (*Proc. Hawaiian Ent. Soc.* 10(2):198, 1939).

Hostplants: *Ipomoea reptans,* "grass," taro, *Monochorius hastata,* garden beans, potato, "water lily."

Rhopalosiphum prunifoliae (Fitch) (fig. 55).

Aphis prunifoliae Fitch, Trans. New York State Agric. Soc. 14:826, 1854 (1855) (I have not seen this reference).

Rhopalosiphum prunifoliae (Fitch) Hottes and Frison, 1931:239, figs. 31, 196.

Hawaii.

Immigrant. A North American species. First discovered in the Hawaiian Islands in Hawaii National Park in 1945 by C. J. Davis.

Hostplant: *Cynodon dactylon.*

In the spring it is found on *Crataegus, Prunus* and *Pyrus* in North America, but in the summer it migrates to grasses. It will probably be a grass-inhabiting species in most or all localities in Hawaii.

Rhopalosiphum pseudobrassicae (Davis) (fig. 56).

Aphis pseudobrassicae Davis, 1914:231, figs. 21, 22.

The turnip aphid.

Kauai, Oahu, Hawaii.

Immigrant. An almost cosmopolitan species. First found in the Hawaiian Islands by Look at Kaneohe, Oahu, in 1939.

Hostplants: broccoli, cardamine, Chinese cabbage, daikon, mustard cabbage, radish, "shirona" (*Brassica* sp.), tomato.

Heavy losses from the attack of this aphid on Chinese cabbage have been reported locally. Nicotine sulphate spray and nicotine dust, however, have given good control.

Genus **COLORADOA** Wilson, 1910:323

Stephensonia Das, 1918:175.

Antennae six-segmented in alates and apterae, sensoria circular, frontal tubercles rudimentary; cornicles elongate, longer than the constricted cauda, somewhat clavate, especially in alatae; anal plate rounded; fore wings with M forked twice, hind wings with M and Cu present; body setae capitate, but inconspicuous.

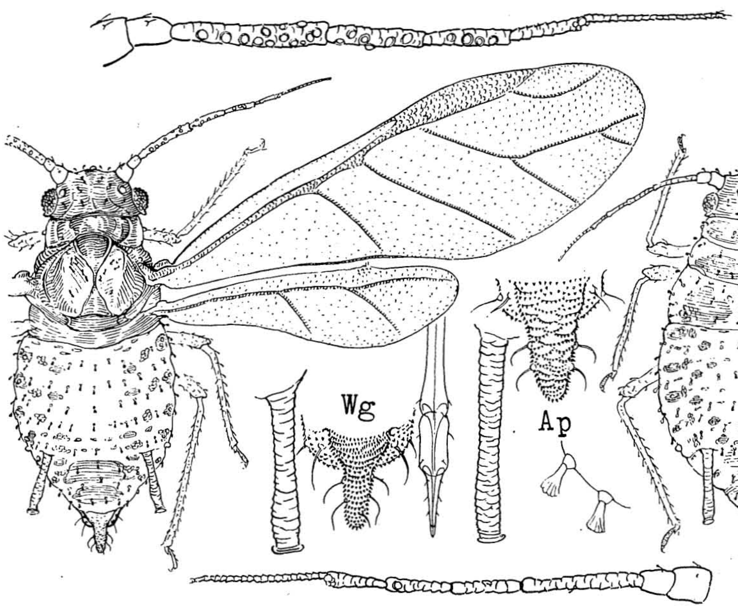


Figure 57—*Coloradoa rufomaculata* (Wilson). (Note: The last four ventral rows of abdominal setae are capitate as on dorsum in alatae and apterae.) (Drawn by Abernathy for this text through the courtesy of E. O. Essig and the Division of Entomology, University of California.)

The capitate setae are only revealed for accurate observation by clearing and staining. Some workers feel that this genus is a synonym of *Rhopalosiphum* and others consider it to be a subgenus.

Coloradoa rufomaculata (Wilson) (fig. 57).

Aphis rufomaculata Wilson, 1908:261.
Coloradoa rufomaculata (Wilson) Wilson, 1910:323.
Stephensonia lahorensis Das, 1918:175.
Siphocoryne lahorensis (Das) Van der Goot, in Das, 1918:179, footnote.
Rhopalosiphum rufomaculatum (Wilson) Baker, 1920:50.

Oahu.

Immigrant. First found in the Hawaiian Islands by D. D. Jensen at Waipahu, Oahu, in 1945. It is a widespread species known from Europe, Asia, Australia and North America.

Hostplant: *Chrysanthemum.*

Jensen (*Proc. Hawaiian Ent. Soc.* 12(3):488, 1946) states that "In life this aphid appears bright green in general color, but has an inconspicuous white bloom due to the numerous small, capitate hairs on the body."

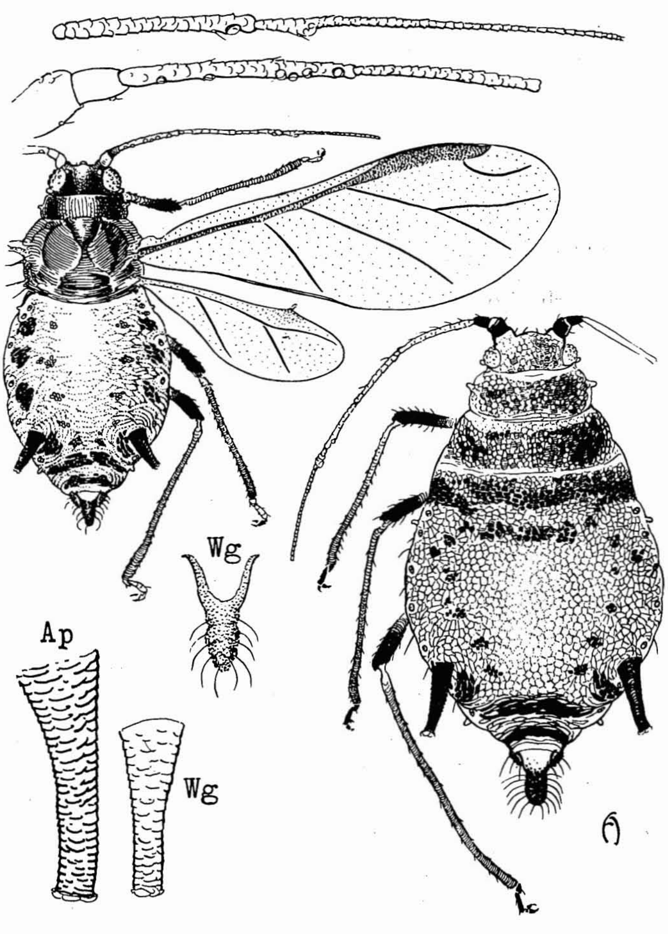


Figure 58—*Toxoptera aurantii* (Boyer de Fonscolombe). The black citrus aphid. (Drawn by Abernathy.)

Genus **TOXOPTERA** Koch, 1856

Antennae six-segmented in both alates and apterae, sensoria circular, frontal tubercles rather feebly developed, cornicles elongate, tapering, longer than the cauda, anal plate rounded, fore wings with only one fork to M, hind wings with M and Cu present, body setae pointed, not strongly developed on dorsum in our species.

This group is much like *Aphis,* and the alates are distinguished by the fact that they have only one fork to M in the fore wings. Some authorities consider *Toxoptera* to be a synonym of *Aphis.*

Key to the Immigrant Species of Toxoptera

(Alate females)

1. Third antennal segment with fewer than six secondary sensoria, fourth and fifth with none; derm of abdomen with a characteristic reticulate sculpturing which is coarsest and conspicuously prominent in vicinity of cornicles, meshes distinctly elongate and appearing coarsely beaded.......... ....**aurantii** (Boyer de Fonscolombe).
2. Third antennal segment with more than 12 secondary sensoria, fourth with about six, fifth usually with about five....... ....**cyperi** Van der Goot.

Toxoptera aurantii (Boyer de Fonscolombe) (fig. 58).
Aphis aurantii Boyer de Fonscolombe, 1841:178.
Toxoptera aurantiae Koch, 1856:254, figs. 329, 330.

The black citrus aphid.

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. Cosmopolitan. Long known in the Hawaiian Islands, but evidently recorded for the first time by Fullaway in 1910.

Hostplants: *Callophyllum inophyllum*, camellia, *Citrus maxima* (pomelo), coffee, *Eugenia sandwicensis* ("ohia ha"), *Ficus*, *Hibiscus arnottianus*, *Hibiscus rosa-sinensis*, *Ilex anomala*, *Ixora macrothyrsa*, *Lagerstroemia indica*, lime, *Macadamia*, mango, *Myrsine lessertiana*, *Myrsine sandwicensis*, *Pelea*, *Pittosporum glabrum*, *Scaevola chamissoniana*, *Straussia*, *Vanda*, *Vaccinium*.

Parasite: *Aphelinus semiflavus* Howard (Hymenoptera: Aphelinidae).

Predators: *Chrysopa microphya* McLachlan (Neuroptera: Chrysopidae); *Platyomus lividigaster* Mulsant, *Coccinella inaequalis* Fabricius (Coleoptera: Coccinellidae); *Allograpta obliqua* Say (Diptera: Syrphidae).

This species has rarely been seen in the lowlands, and it is principally a species of the mountains and cultivated areas at higher elevations. Timberlake (1924: 454–455) noted that it had never been taken on *Citrus* in Hawaii, "probably because of its rarity in the lowlands, where most of the Citrus trees are grown." It congregates on the tender young shoots of its hostplant.

Toxoptera cyperi Van der Goot (fig. 59).
Toxoptera cyperi Van der Goot, 1917:81.

The nutgrass aphid.

Oahu, Maui.

Immigrant. Described from Java. First found in the Hawaiian Islands by Pemberton at Honolulu in 1939 and identified by Essig in 1945.

Hostplants: *Cyperus rotundus* (nutgrass), *Santalum haleakalae*.

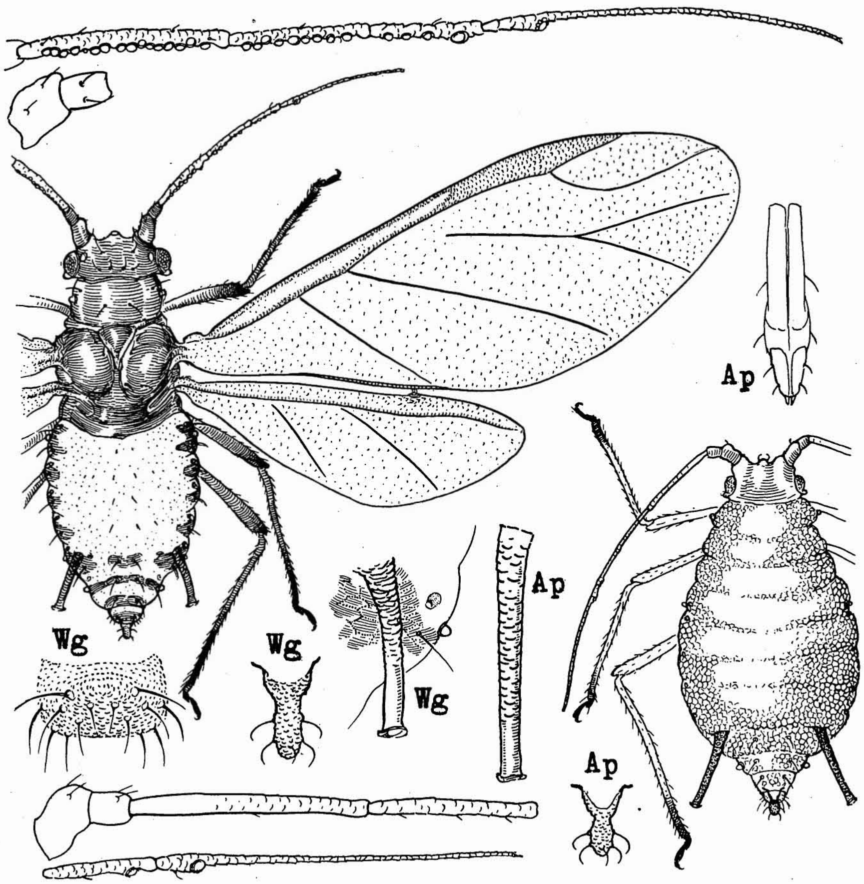


Figure 59—*Toxoptera cyperi* Van der Goot. The nutgrass aphid. (Drawn by Abernathy for use in this text through the courtesy of E. O. Essig and the division of Entomology, University of California.)

This species had been collected only from nutgrass brought in from the field to feed caterpillars at the Experiment Station, Hawaiian Sugar Planters' Association, in Honolulu, before I collected it from *Santalum* on Maui in 1945.

Genus **VESICULAPHIS** Del Guercio, 1911:463

Antennae six-segmented in alates, five-segmented in apterae, sensoria subcircular and subtubercular, frontal tubercles not developed, but top of head extending somewhat out over antennal bases, cornicles elongate, longer than the tapering cauda, swollen, constricted subapically, anal plate rounded, M with one fork in fore wings, hind wings with M and Cu present.

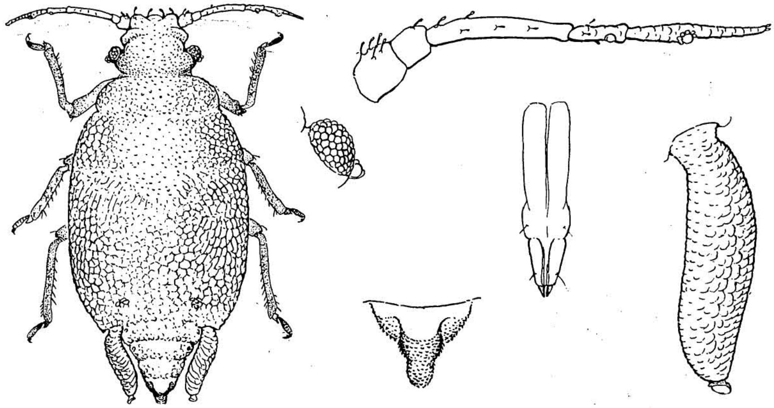


Figure 60—*Vesiculaphis caricis* (Fullaway), details of apterous female. (Drawn for this text by Abernathy through the courtesy of E. O. Essig and the Division of Entomology, University of California.)

Vesiculaphis caricis (Fullaway) (fig. 60).

Toxoptera cariçis Fullaway, 1910:32.

Vesiculaphis caricis (Fullaway) Del Guercio, 1911:464. Genotype.

Oahu (type locality: Pauoa Valley, 1,500–2,000 feet).
Immigrant. Source undetermined.
Hostplants: "a species of *Carex*," tomato.

Subtribe Macrosiphina

Genus **AMPHOROPHORA** Buckton, 1876

Antennae six-segmented in both alates and apterae, sensoria prominent and circular, frontal tubercles distinct, cornicles elongate, longer than cauda, distinctly swollen, cauda constricted, anal plate rounded, fore wings with two forks to M, hind wings with M and Cu present, body hairs not greatly developed.

See Mason (1925) for detailed discussion and revision of the genus.

Key to the Species of Amphorophora Established in Hawaii

1. Cornicles distinctly reticulated at apices; alates without secondary sensoria on fourth antennal segment, only 12 to 16 on third segment........................... **vaccinii** Mason.
2. Cornicles with a slight imbricated sculpture at apex, but not reticulate; alates with 10 to 18 secondary sensoria on fourth antennal segment, 40 or more on third segment.. **sonchi** (Oestlund).

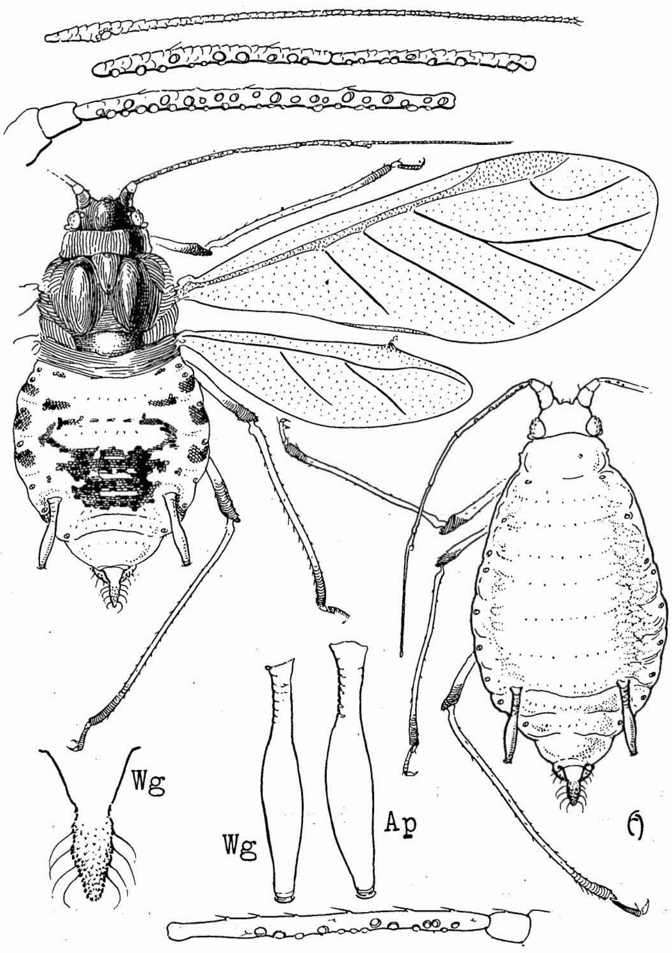


Figure 61—*Amphorophora sonchi* (Oestlund), the *Sonchus* aphid. (Drawn by Abernathy.)

Amphorophora sonchi (Oestlund) (fig. 61).
Rhopalosiphum sonchi Oestlund, 1886:34.

The *Sonchus* aphid.

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. A widespread species. First recorded from the Hawaiian Islands by Timberlake in 1922 when he misidentified it as *Amphorophora lactucae* (Kaltenbach).

Hostplants: papaya, *Sonchus oleraceus,* sweet potato, tomato.

This species is widespread here and breeds in large numbers on *Sonchus.*

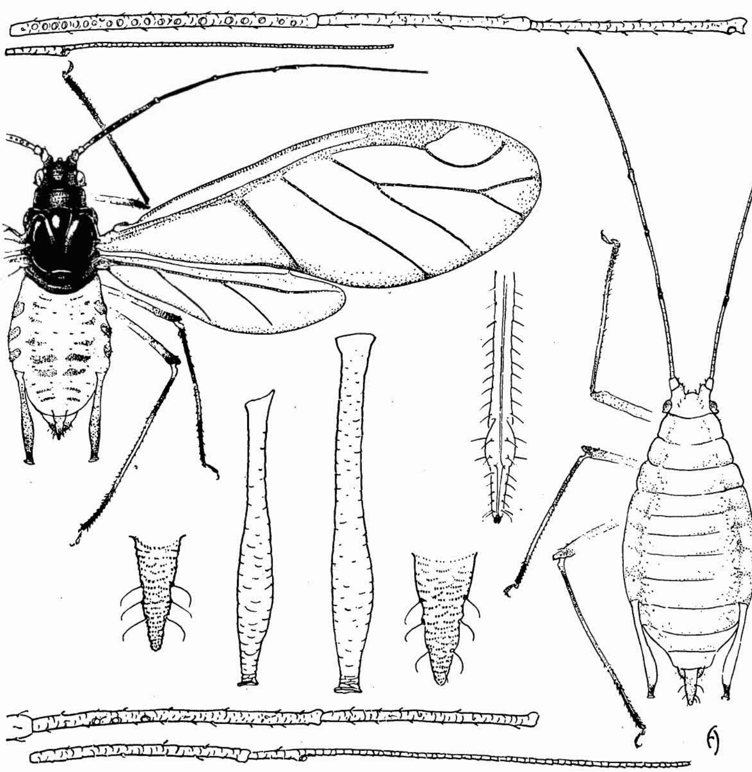


Figure 62—*Amphorophora vaccinii* Mason. (Drawn by Abernathy, and used through the courtesy of E. O. Essig and the Division of Entomology, University of California.)

Amphorophora vaccinii Mason (fig. 62).
Amphorophora vaccinii Mason, 1925:67, figs. 179–188, 191–192.

Hawaii.

Immigrant. Described from the eastern United States. First found in the Hawaiian Islands by C. J. Davis at 6,500-foot elevation at the end of the Mauna Loa truck trail on Hawaii in 1946.

Hostplant: *Vaccinium reticulatum.*

Genus **CAPITOPHORUS** Van der Goot, 1913

Antennae six-segmented in alates and apterae, sensoria prominent and subcircular, frontal tubercles well developed, cornicles elongate, subcylindrical, much longer than the tapering or upturned cauda, anal plate rounded, fore wings with two forks to M, hind wings with both M and Cu present, body hairs capitate, especially in the apterae.

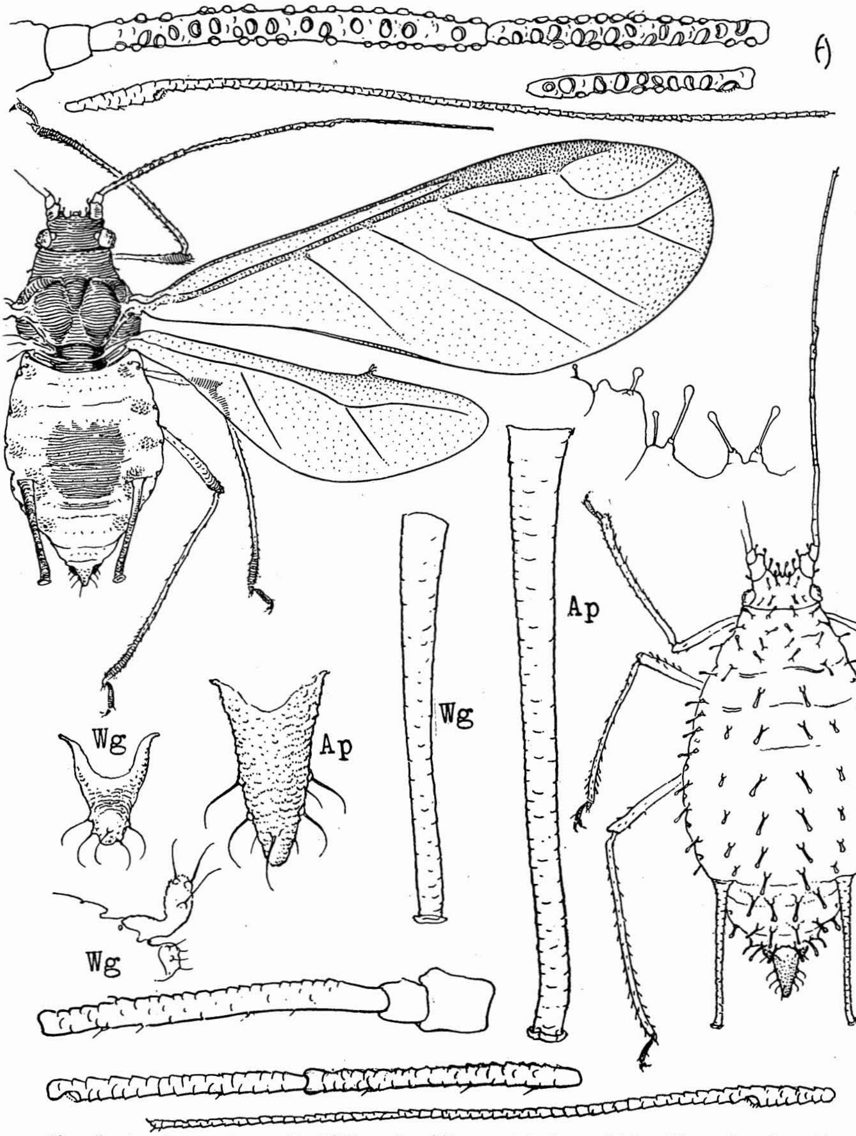


Figure 63—*Capitophorus braggii* (Gillette). The artichoke aphid. (Drawing by Abernathy.)

Key to the Species of Capitophorus Established in Hawaii

1. Alates 2
   Apterae 3

2(1). Capitate hairs on body not prominent; antennae shorter than a fore wing, segment 3 much longer than 4, sensoria multitudinous on segments 3, 4 and 5..... **braggii** (Gillette).
   Capitate hairs on body large and conspicuous; antennae longer than a fore wing, segment 3 subequal in length to 4, secondary sensoria confined to segment 3........ .... **chrysanthemi** Theobald.

3(1). Cornicles subequal in length to fore tibiae; sixth antennal segment much longer than segments 5 plus 4 (as long as 5 plus 4 plus about one-half of 3); on artichoke.... .... **braggii** (Gillette).

Cornicles much shorter than fore tibiae; sixth antennal segment hardly longer than segments 5 plus 4; on chrysanthemums.................... **chrysanthemi** Theobald.

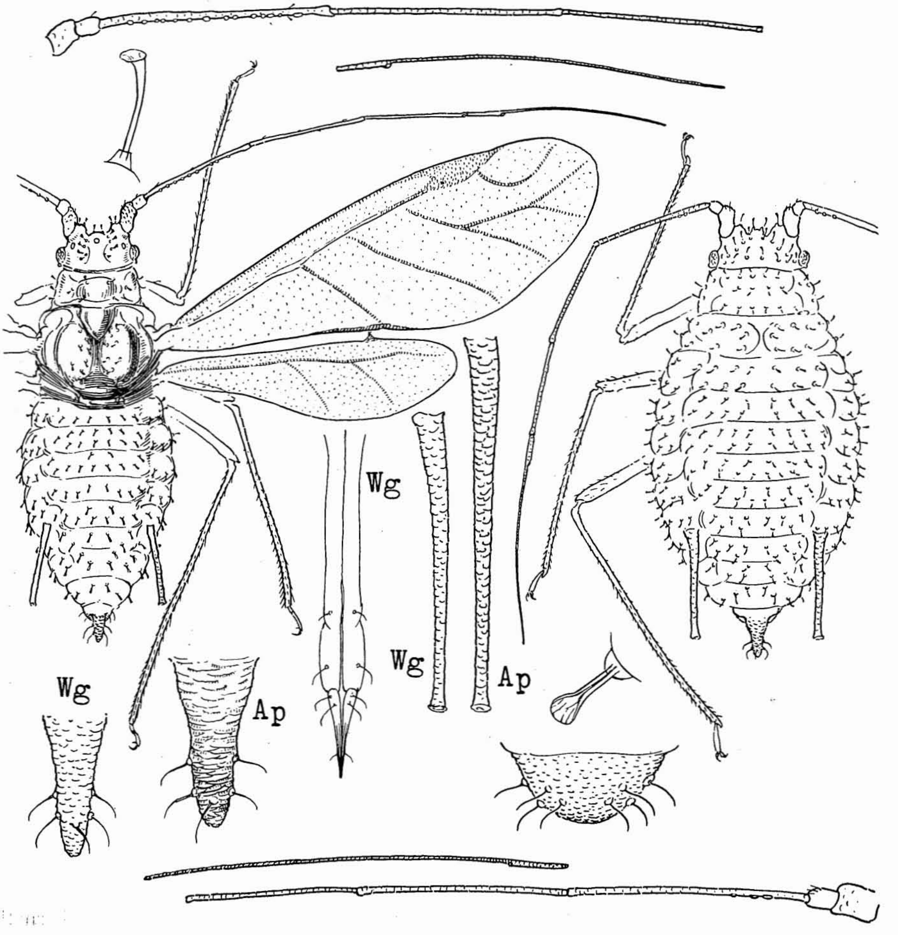


Figure 64—*Capitophorus chrysanthemi* Theobald. (Drawing made for this text by Abernathy and used through the courtesy of E. O. Essig and the Division of Entomology, University of California.) See also figure 65.

Capitophorus braggii (Gillette) (fig. 63).
Myzus braggii Gillette, 1908:17, pl. 1, figs. 1–3.

The artichoke aphid.
Oahu, Maui, Hawaii.

Immigrant. A North American species first noticed in Hawaii by Swezey, who found it in Manoa Valley, Honolulu, in 1923.

Hostplant: artichoke, *Gerbera* (African daisy).

The very long cornicles and prominent, capitate body hairs of the apterous females are conspicuous characters for the recognition of this species in Hawaii.

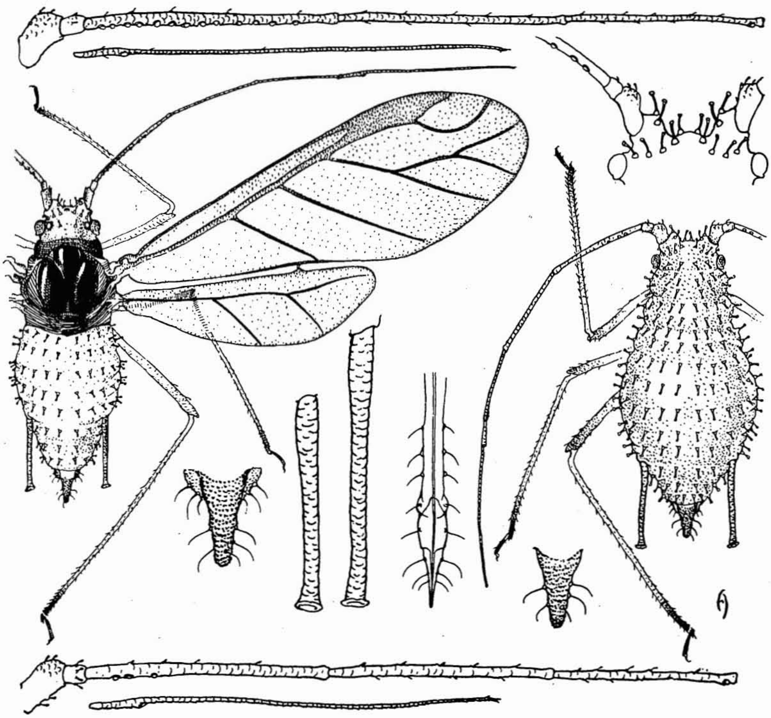


Figure 65—*Capitophorus chrysanthemi* Theobald. (Drawing by Abernathy and supplied through the courtesy of E. O. Essig and the Division of Entomology, University of California.) Compare figure 64.

Capitophorus chrysanthemi Theobald (figs. 64, 65).

Capitophorus chrysanthemi Theobald, 1920:69, fig. 4.

Oahu.

Immigrant. Described from South Africa, but apparently of Oriental origin. First found in the Hawaiian Islands by D. D. Jensen at Waipahu, Oahu, in 1945.

Hostplant: *Chrysanthemum.*

Jensen (*Proc. Hawaiian Ent. Soc.* 12 (3): 487, 1946) says that the material found by him was "pale green in color, and, in gross appearance resembled the potato aphid, *Macrosiphum solanifolii* (Ashmead), except that *C. chrysanthemi* is somewhat smaller and has darker, more conspicuous wing veins." This species is recorded elsewhere as a pest of chrysanthemums.

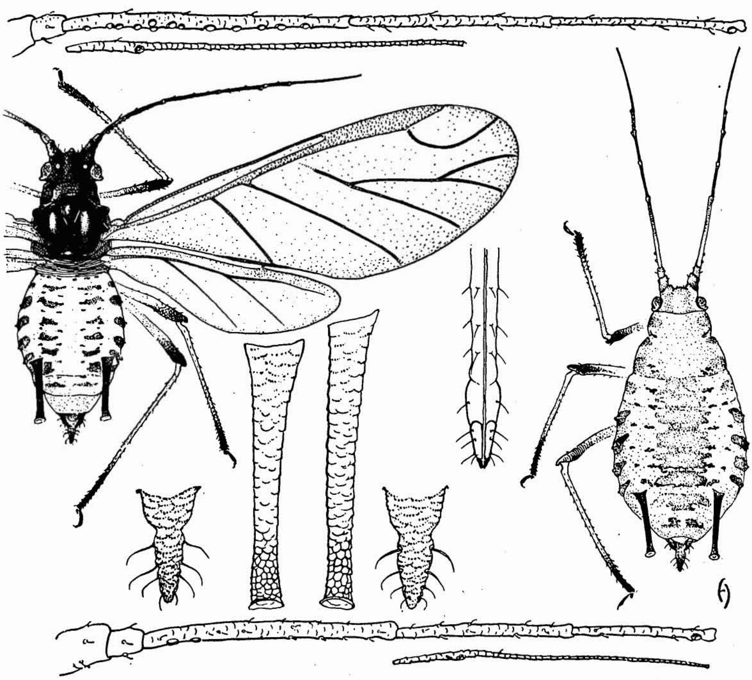


Figure 66—*Macrosiphum granarium* (Kirby). The English grain aphid. (Drawn for this text by Abernathy through the courtesy of E. O. Essig and the Division of Entomology, University of California.)

Genus **MACROSIPHUM** Passerini, 1860

Antennae six-segmented in alatae and apterae, sensoria subcircular; frontal tubercles well developed; cornicles long, cylindrical, longer than the long, tapering cauda in most species; anal plate rounded; fore wings with two forks to M, M and Cu present in hind wings; body setae blunt or slightly capitate; hind tibiae very long, two-thirds as long to as long as the body.

Key to the Species of Macrosiphum Found in Hawaii

1. Cornicles imbricate but without any reticulate sculpture (body setae rather inconspicuous; cornicles in alates not quite as long as cauda, slightly more than twice as long as cauda in apterae) .... **rosaefolium** Theobald.
   Cornicles with at least some reticulate sculpturing near apex 2

2(1). Cornicles only about as long as cauda, reticulate sculpture extending over about two-thirds their length (body setae long and bristling, conspicuous) .... **sanborni** Gillette.

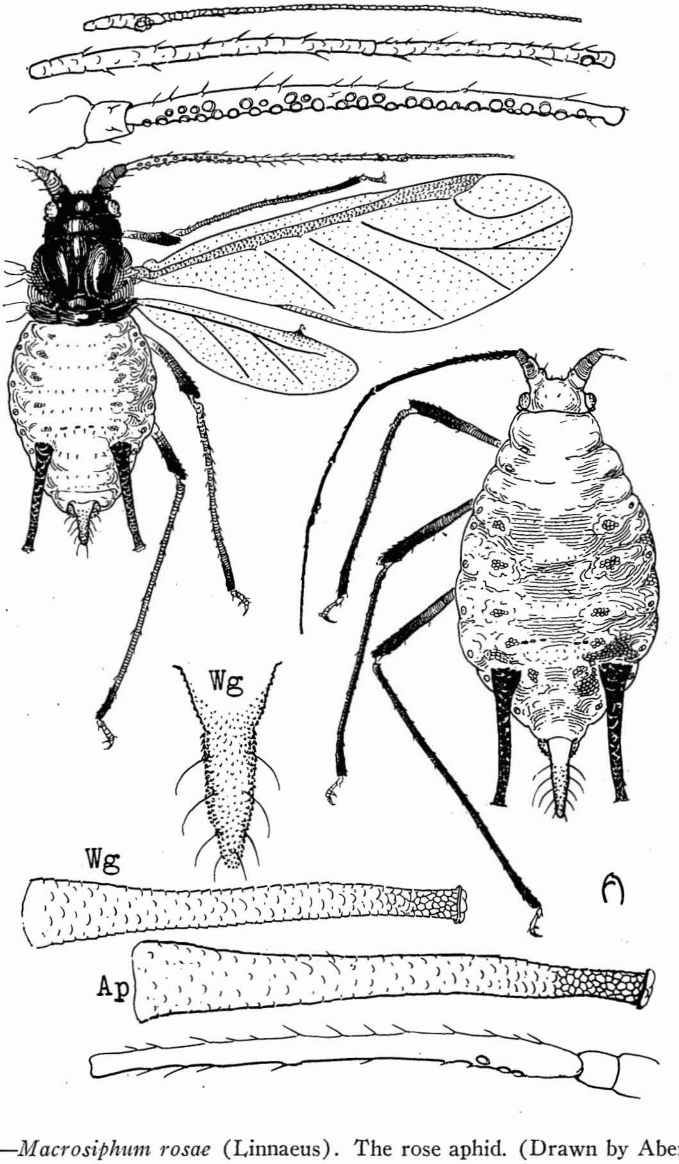


Figure 67—*Macrosiphum rosae* (Linnaeus). The rose aphid. (Drawn by Abernathy.)

Cornicles longer than cauda, only subapically reticulately sculptured (do not confuse ordinary imbricate sculpturing for the reticulate pattern)........................ 3

3(2). Third antennal segment of alate female with more than 30 irregularly placed sensoria..............**rosae** (Linnaeus).

Third antennal segment of alate female with not more than 20 sensoria and these mostly arranged in a straight line... 4

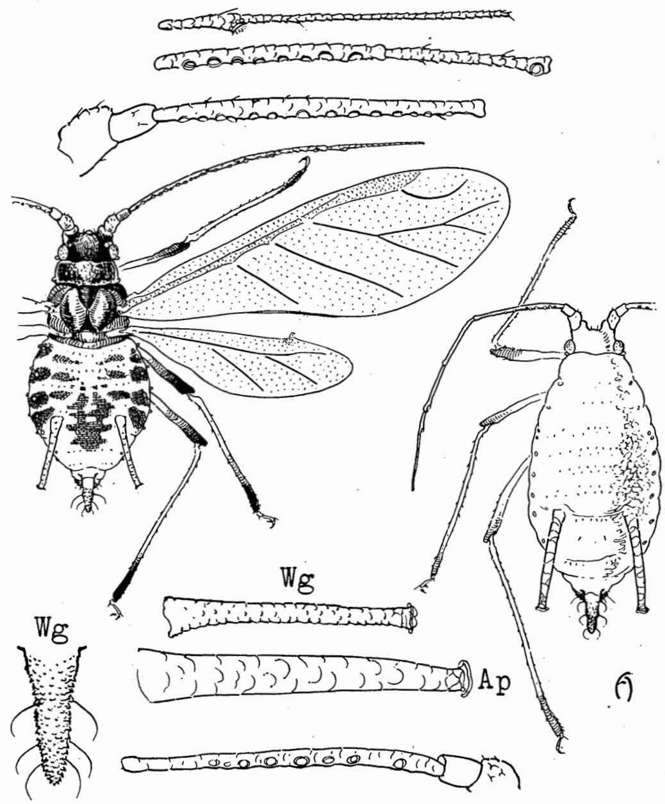


Figure 68—*Macrosiphum rosaefolium* Theobald. The rose-leaf aphid. (Drawn by Abernathy.)

4(3). Cornicles longer than third antennal segment; not a grass feeder .... **solanifolii** (Ashmead).
Cornicles shorter than third antennal segment; on grasses .... **granarium** (Kirby).

Macrosiphum granarium (Kirby) (fig. 66).
Aphis granaria Kirby, 1798:238.

The English grain aphid.

Maui.

Immigrant. Described from England; now widespread. First recorded in the Hawaiian Islands from specimens collected in 1945 in Haleakala Crater by C. J. Davis. However, I believe that Swezey and I, and perhaps other workers, had observed this species on Haleakala some years earlier.

Hostplant: *Deschampsia hawaiiensis.*

This is a species of considerable economic interest in temperate regions, and a large amount of literature has been built up around it. It is a pest of cereals.

Macrosiphum rosae (Linnaeus) (fig. 67).
Aphis Rosae Linnaeus, 1758:452.

The rose aphid.

Oahu, Maui, Hawaii.

Immigrant. An almost cosmopolitan species first reported from the Hawaiian Islands by Kirkaldy in 1906 (1907:100).

Hostplant: rose.

Predators: *Coccinella repanda* Thunberg, *Orcus chalybeus* (Boisduval) (Coleoptera: Coccinellidae); *Ischiodon scutellaris* (Fabricius) (Diptera: Syrphidae).

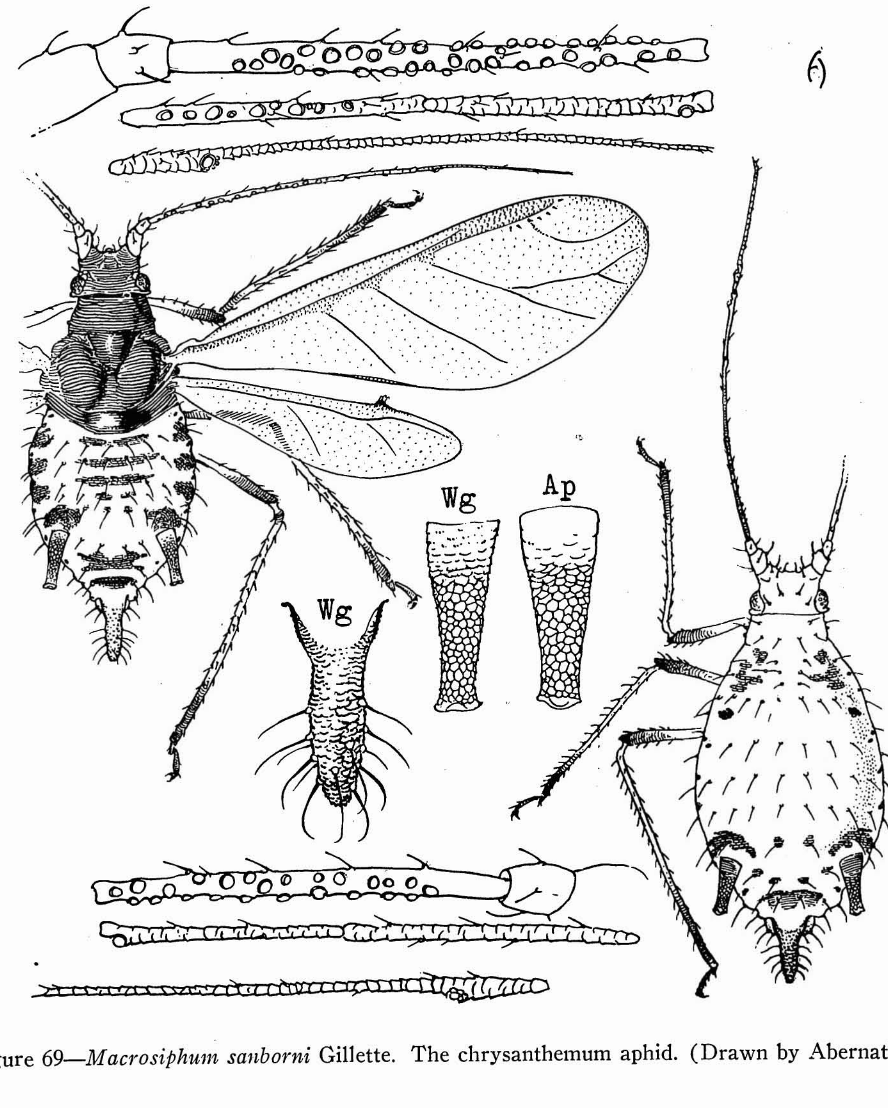


Figure 69—*Macrosiphum sanborni* Gillette. The chrysanthemum aphid. (Drawn by Abernathy.)

Macrosiphum rosaefolium Theobald (fig. 68).

Macrosiphum rosaefolium Theobald, 1915:109, fig. 4.

The rose-leaf aphid.

Kauai, Oahu.

Immigrant. A widespread species evidently first found in Hawaii in 1916 by Timberlake at Honolulu.

Hostplant: rose.

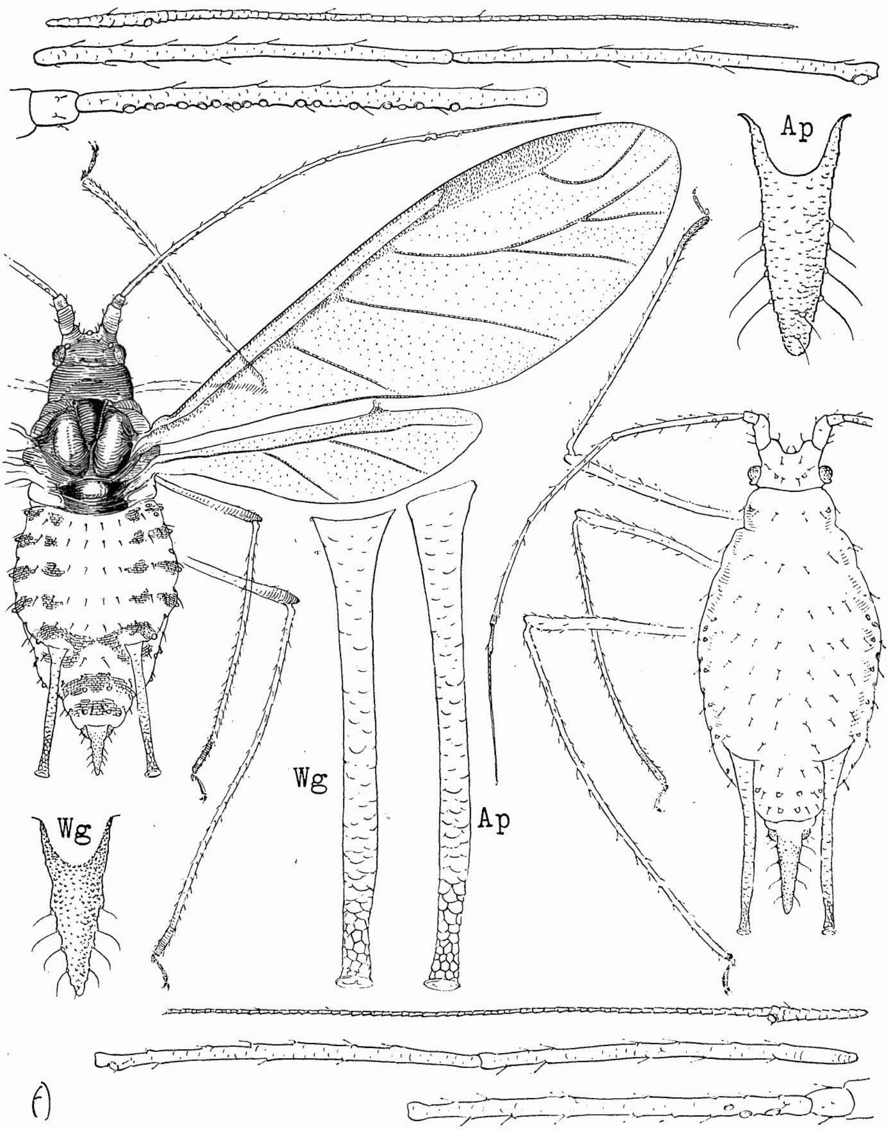


Figure 70—*Macrosiphum solanifolii* (Ashmead). The potato aphid. (Drawn by Abernathy.)

Macrosiphum sanborni Gillette (fig. 69).
Macrosiphum sanborni Gillette, 1908:65, pl. 3, figs. 8, 9.
Macrosiphoniella sanborni (Gillette), Timberlake, 1924:458.

The chrysanthemum aphid.
Oahu.
Immigrant. Described from North America and first reported from the Hawaiian Islands by Fullaway (1910:26), who found it at Honolulu in 1909.
Hostplant: *Chrysanthemum.*
For a noteworthy discussion of the environmental conditions affecting the production of wings in this species, see White, 1946:245. She found that a number of factors influence wing development, but the effect of light is most important.

Macrosiphum solanifolii (Ashmead) (fig. 70).
Siphonophora solanifolii Ashmead, 1882:92.
Macrosiphum trifolii Pergande, 1904:21, fig. 4.

The potato aphid.
Oahu, Maui, Hawaii.
Immigrant. A widespread species which appears to have been reported first from Hawaii by Fullaway (1910), who took it on Mount Tantalus, Honolulu, in 1909.
Hostplants: *Arctium lappa,* broccoli, celery, corn, *Deschampsia,* Easter lily, edible podded pea, eggplant, *Hypochaeris radicata,* lettuce, papaya, *Portulaca,* potato, *Sonchus oleraceus,* sweet potato, tomato, white mustard cabbage, zucchini.
This species has also appeared in Hawaiian literature or collections as *Macrosiphum gei* (Koch) and *Macrosiphum euphorbiae* (Thomas).

Genus **MYZUS** Passerini, 1860

Antennae six-segmented in alatae and apterae, sensoria subcircular, antennal tubercles well developed; cornicles long and cylindrical, much longer than the tapering cauda; anal plate rounded; fore wings with M twice-branched, hind wings with both M and Cu present; body hairs blunt or feebly capitate.
Mason (1940:1–30) has revised the North American species of this genus.

Key to the Species of Myzus Established in Hawaii

1. Alatae 2
   Apterae 5
2(1). Cornicles more than twice as long as cauda 3
   Cornicles less than twice as long as cauda 4
3(2). Abdomen with a mostly continuous, large, dark dorsal median patch which does not tend to form transverse bands; antennae shorter than body; rostrum not reaching mesocoxae . . . . **ornatus** Laing.
   Abdomen with the large dark median area forming transverse bands or tending to form such a pattern; antennae

longer than body; rostrum extending behind mesocoxae ....**convolvuli** (Kaltenbach).

4(2). Third antennal segment with 14 or more sensoria, usually more ....**circumflexus** (Buckton).
Third antennal segment with not more than 14 sensoria, usually fewer than 12..................**persicae** (Sulzer).

5(1). Dorsum with conspicuous dark markings................ 6
Dorsum without dark maculae.......................... 7

6(5). Antennae much shorter than body...........**ornatus** Laing.
Antennae about as long as body or longer............. ....**circumflexus** (Buckton).

7(5). Antennae obviously longer than entire body from frontal tubercles to end of cauda.........**convolvuli** (Kaltenbach).
Antennae shorter than median body length............ ....**persicae** (Sulzer).

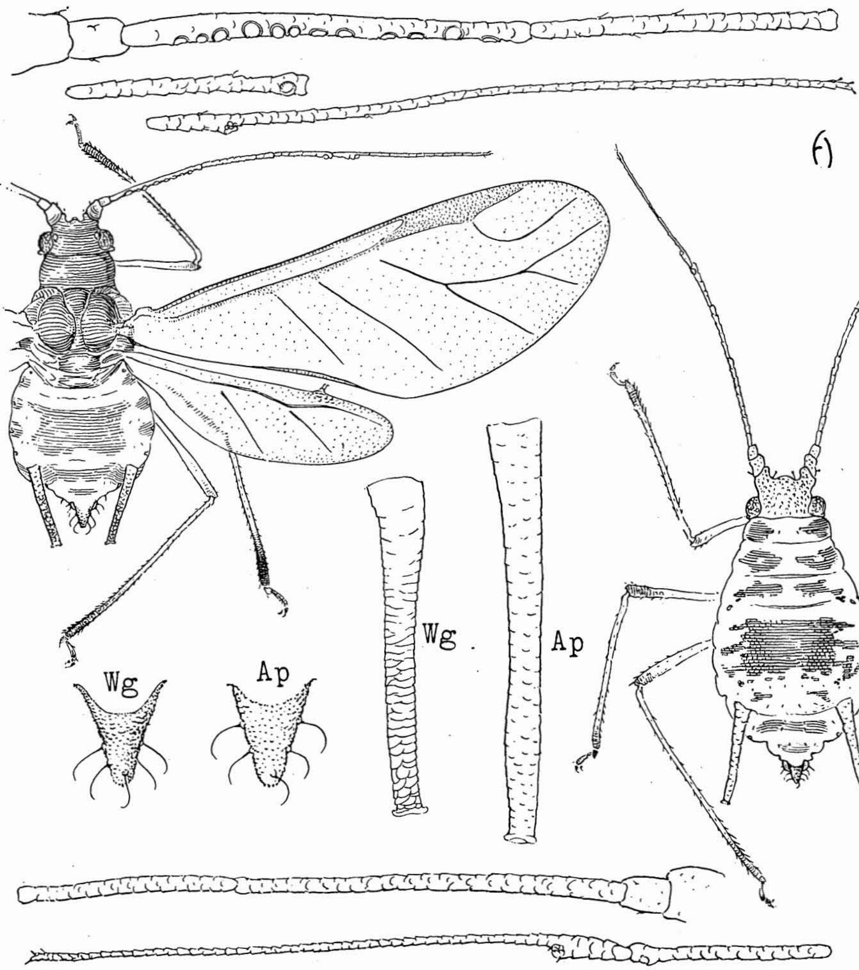


Figure 71—*Myzus circumflexus* (Buckton). The lily aphid. (Drawn by Abernathy.)

Myzus circumflexus (Buckton) (fig. 71).
Siphonophora circumflexa Buckton, 1876:130, pl. 13.
Aulacorthum circumflexum (Buckton), Timberlake, 1924:457.

The lily aphid.

Oahu, Maui, Hawaii.

Immigrant. A widespread species, first recorded from Hawaii by Fullaway in 1909 (1910:26) from specimens collected by him on Mount Tantalus, Honolulu.

Hostplants: *Arctium lappa, Hemerocallis, Hibiscus,* papaya, *Phyllostegia grandiflora, Physalis peruviana* ("poha"), rose, *Vaccinium, Viola* (endemic shrubby species), *Viola tricolor* (pansy).

Parasite: *Aphelinus semiflavus* Howard (Hymenoptera: Aphelinidae).

"It is a rather large, robust, pale-green or yellow aphid, the apterous forms immaculate or with distinct dark markings on the dorsum . . . and the winged forms with a considerable portion of the body black. The dark dorsal patches on the abdomen and the rather short, smooth, black-tipped cornicles are good superficial diagnostic characters." (Essig, 1938:476.)

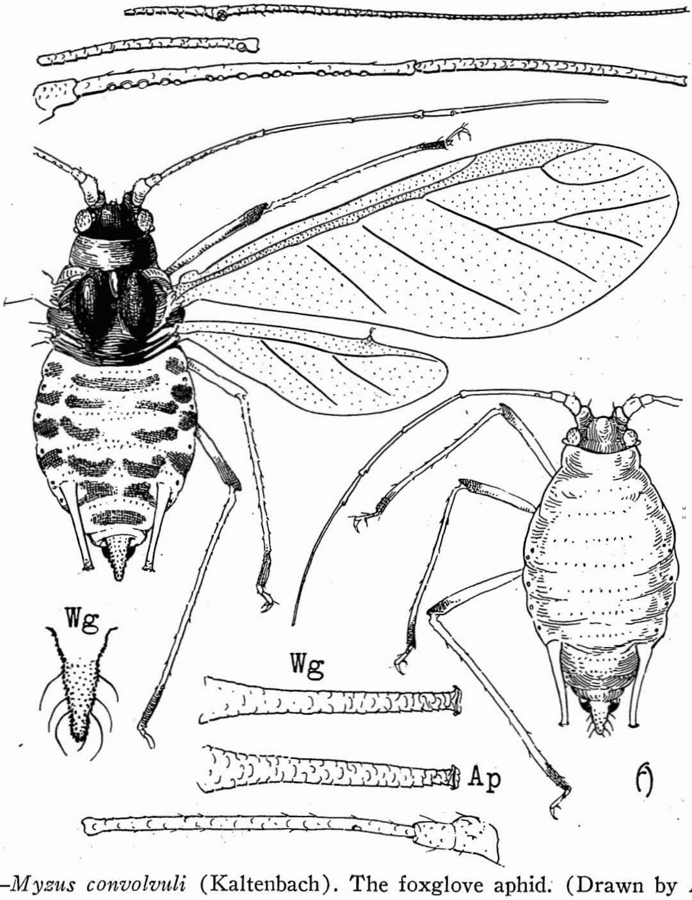


Figure 72—*Myzus convolvuli* (Kaltenbach). The foxglove aphid. (Drawn by Abernathy.)

Myzus convolvuli (Kaltenbach) (fig. 72).
Aphis convolvuli Kaltenbach, 1843:40.

The foxglove aphid.

Oahu, Molokai, Hawaii.

Immigrant. This widespread species was first collected in Hawaii by William Look in 1939 when it was found in Honolulu.

Hostplants: cardamine, cucumber, *Euphorbia boolceri, Kokia cookei, Kokia rockii, Phalaenopsis,* rhubarb, rose, *Spathoglottis plicata.*

Apterae robust, whitish, yellowish, greenish or bright green, immaculate or with a darker green patch at base of each cornicle; apices of antennal segments 3 to 5 and most of 6 dark; apices of femora and tibiae, all of tarsi and apices of cornicles dark. Alatae yellowish to green with dark markings, the broken abdominal bands and black-tipped cornicles being characteristic. The most conspicuous anatomical character is the short, imbricated tip of the long, cylindrical, somewhat tapering, apically flanged cornicles. Length 2.0–2.5 mm. (From Essig, 1938:480–481.) "The individuals have a clever way of standing head down, exuding a drop of honeydew, and then kicking it off with the hind legs, an operation not previously observed by the writer." (Essig, 1938:481.) Essig informs me that this species is called *Myzus solani* (Kaltenbach) or *Aulacorthum solani* (Kaltenbach) by some workers.

Myzus ornatus Laing (fig. 73).
Myzus ornatus Laing, 1932:52. Essig, 1938:92–95, fig. 1. Mason, 1940:14, fig. 4, AA–FF.

The ornate aphid.

Oahu, Maui, Hawaii.

Immigrant. Described from the British Isles and known from western Europe and North America, but probably widespread now. First found by me in the Hawaiian Islands at Honolulu in 1944 (*Proc. Hawaiian Ent. Soc.* 12 (2):227, 1945).

Hostplants: *Beloperone,* cardamine, celery, an "unidentified composite," rhubarb.

The type series was obtained from leaf rolls on violets, which plants were damaged by the attack. We may expect to find it attacking *Lantana, Crotalaria, Chrysanthemum, Buddleia,* dandelion, strawberry, violet and other plants in Hawaii, for it is recorded from all these and others elsewhere. It has been redescribed in detail by Essig.

Myzus persicae (Sulzer) (fig. 74).
Aphis persicae Sulzer, Abgekürzte Geschichte der Insecten nach dem Linnéischen System. Winterthur, H. Steiner Co., p. 105, 1776 (I have not seen this reference).

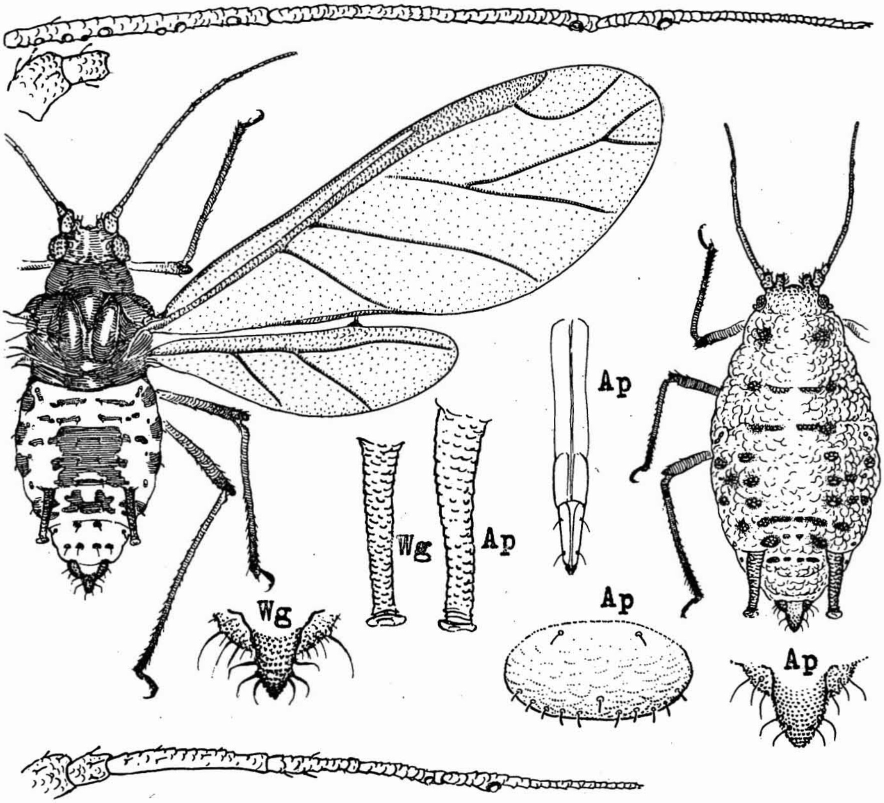


Figure 73—*Myzus ornatus* Laing. The ornate aphid. (Drawn for this text by Abernathy through the courtesy of E. O. Essig and the Division of Entomology, University of California.)

The green peach aphid.

Kauai, Oahu, Maui, Hawaii.

Immigrant. An almost cosmopolitan species first recorded from the Hawaiian Islands by Fullaway (1910:28), who found it at Honolulu.

Hostplants: *Arctium lappa* ("gobo" or great burdock), beet, *Beloperone, Brassica* sp., broccoli, cardamine, carrot, cauliflower, Chinese cabbage, *Crotalaria mucronata,* daikon radish, *Datura stramonium, Deschampsia,* Easter lily, eggplant, garden bean, head cabbage, kale, lettuce, *Moraea iridiodes,* papaya, pepper, potato, tomato, "shirona" (*Brassica* sp.), sweet potato.

Parasite: *Diaretus chenopodiaphidis* Ashmead (Hymenoptera: Braconidae).

This species has been considered a minor bean pest in recent years and is one of our economically important species. Essig believes it to be the most important aphid vector of plant diseases. Since this text was completed, it has been found to carry papaya ringspot disease in Hawaii.

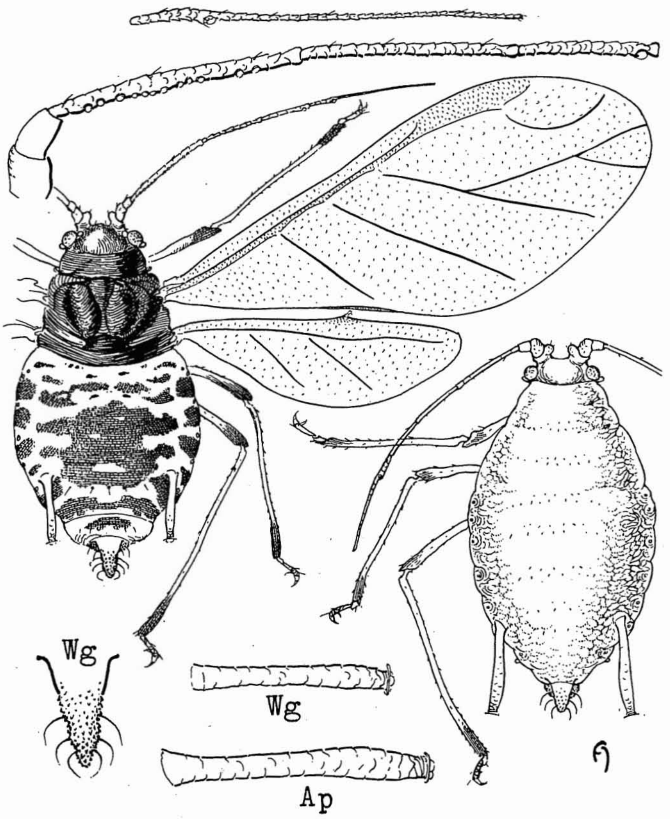


Figure 74—*Myzus persicae* (Sulzer). The green peach aphid. (Drawn by Abernathy.)

Essig (1938:482–484) notes that yellow, green, or pinkish individuals may occur in the same colony. "The wingless forms are without markings on the body proper. In the winged forms, the head, appendages, much of the thorax, and a conspicuous dorsal abdominal blotch and small lateral patches are dusky or black. The third antennal segment of the winged form has a row of circular sensoria; and the cornicles are somewhat swollen."

Genus **PHORODON** Passerini, 1860

Antennae six-segmented in alates and apterae, sensoria subcircular, first segment with an inwardly projecting swelling or process, frontal tubercles produced into elongated processes; cornicles elongate, longer than the conical cauda; fore wings with M forked twice, M and Cu present in hind wings; body setae blunt.

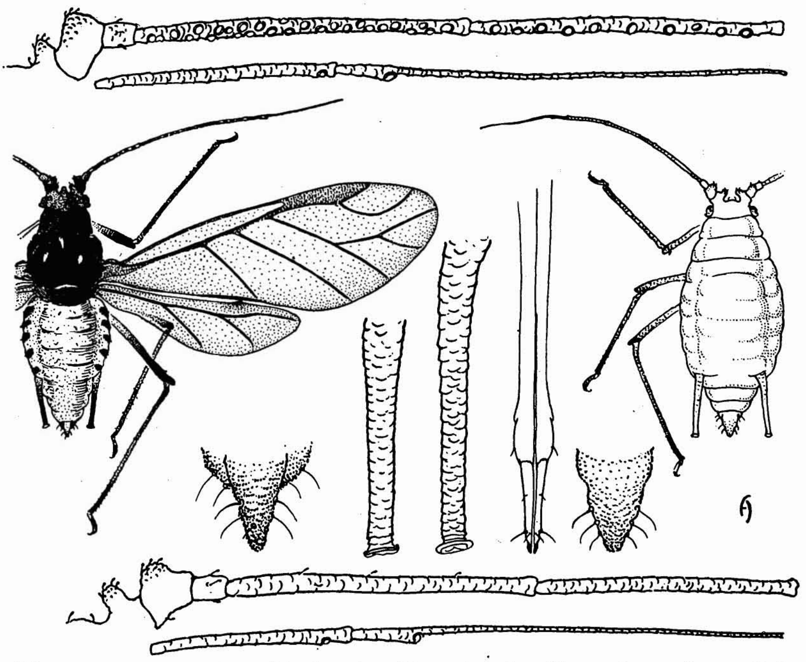


Figure 75—*Phorodon menthae* (Buckton). (Drawing by Abernathy and supplied through the courtesy of E. O. Essig and the Division of Entomology, University of California.)

Phorodon menthae (Buckton) (fig. 75).
Siphonophora menthae Buckton, 1876:120.

The mint aphid.

Hawaii.

Immigrant. Described from England. First discovered in the Hawaiian Islands by C. J. Davis at Paio, Hawaii, 3,900-foot elevation, in 1946.

Hostplant: *Mentha* (mint).

"Yellow green to apple green, mottled with darker, alate with head and thorax dark brown; cauda, cornicles and tibiae pale; antennae dusky; veins more or less heavy." (Gillette and Palmer, 1934:208.)

Subtribe PENTALONINA

Genus **MICROMYZUS** Van der Goot, 1917

Antennae six-segmented in alatae and apterae, sensoria subcircular, frontal tubercles well developed; cornicles elongate, swollen, longer than the tapering cauda; anal plate rounded; fore wings with M twice-forked, hind wings with M and Cu present, both wings infumated along the veins in our species; body setae not strongly developed.

Key to the Species of Micromyzus Found in Hawaii

1. Terminal filament of sixth antennal segment not as long as third segment; alates with numerous prominent sensoria on antennal segment 4 and several on 5; wing venation as in figure 76.......................... **formosanus** (Takahashi).
2. Terminal filament of sixth antennal segment as long as or longer than segments 3 plus 2 combined; antennal segments 4 and 5 without numerous sensoria; wing venation as in figure 77.............................. **violae** (Pergande).

Micromyzus formosanus (Takahashi) (fig. 76).
Fullawayella formosanus Takahashi, 1921:39, pl. 3 (2), figs. 1–5.

The onion aphid.

Kauai, Oahu, Maui, Hawaii.

Immigrant. Described from Formosa, but now known to be more widely spread in the Old and New World. First recorded in Hawaii from specimens taken at Kaneohe, Oahu, in 1939 by Look, but known to other collectors as an unidentified species collected a number of years previously.

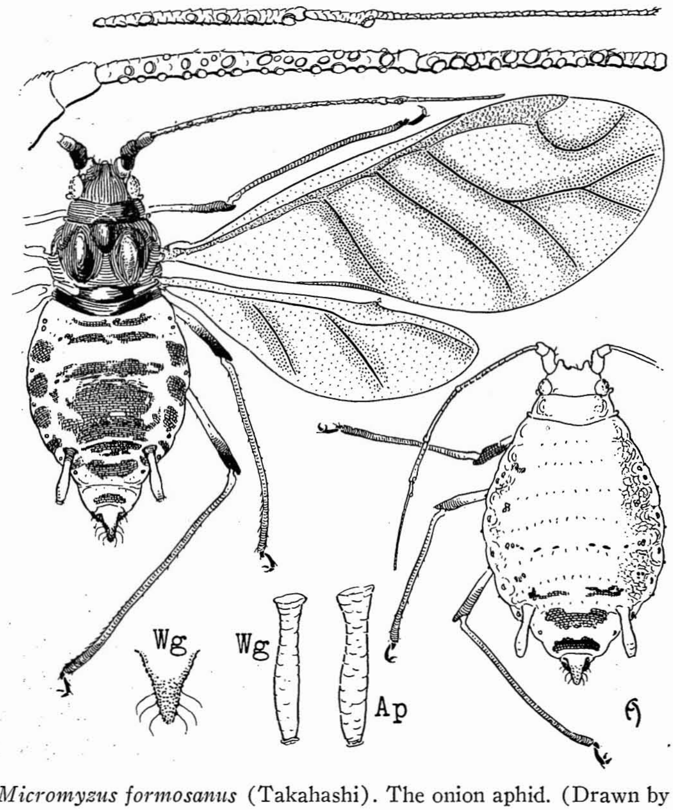


Figure 76—*Micromyzus formosanus* (Takahashi). The onion aphid. (Drawn by Abernathy.)

Hostplants: *Allium fistulosum,* chive, Japanese onion, onion, pole bean.

The following note appears in *Proc. Hawaiian Ent. Soc.* 12 (2) : 221, 1945:

Mr. Pemberton exhibited the tops of some California dried onions which had sprouted in a screened cooler in his house after having been held in the cooler for a month. The green sprouts had developed a large colony of this onion aphis. In his opinion, this demonstrates how the aphis could have been introduced into Hawaii from California. When the onions were purchased they had no sprouts, but undoubtedly carried some of the aphis concealed beneath the loose scales at the apex of the affected bulbs.

Micromyzus violae (Pergande) (fig. 77).
Rhopalosiphum violae Pergande, 1900:29.
Neotoxoptera violae (Pergande), Timberlake, 1924:458.

The violet aphid.
Oahu, Hawaii (?).

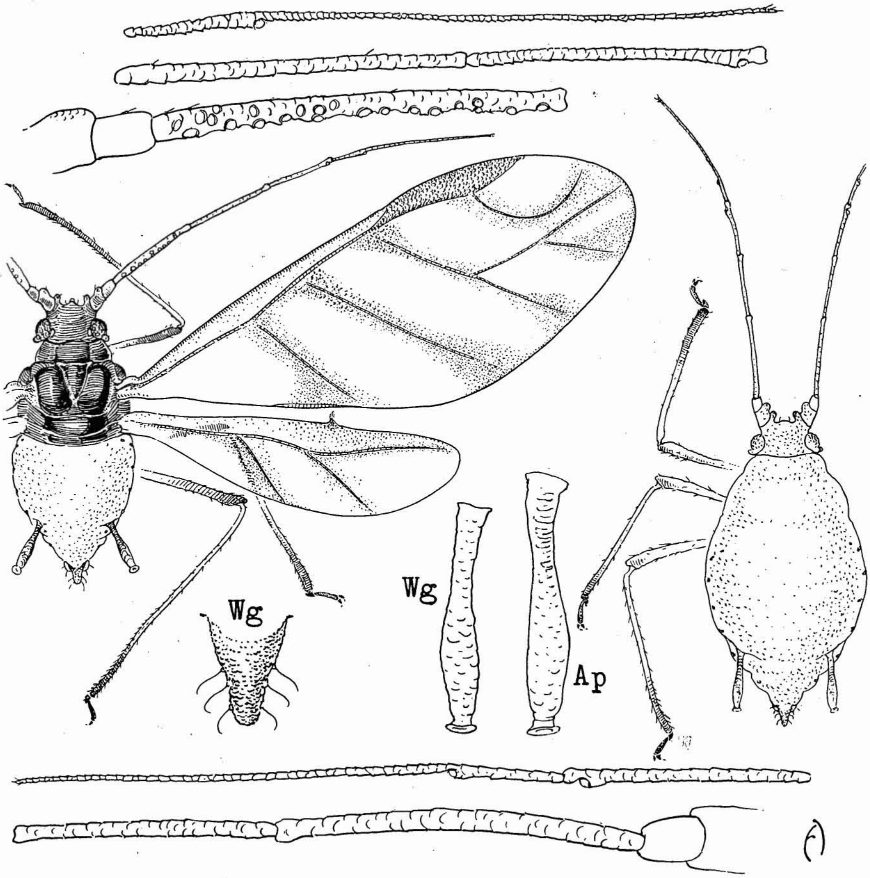


Figure 77—*Micromyzus violae* (Pergande). The violet aphid. (Drawn by Abernathy.)

Immigrant. First described from hothouse violets from Washington, D. C., but now known to be widespread. It was first recorded from the Hawaiian Islands by Fullaway (1910:30) from specimens taken on Mount Tantalus, Honolulu, although Fullaway presumed that it was the same species as an unidentified aphid noted by Kirkaldy as having been found some years previously at Puuopelu, Hawaii.

Hostplant: common violet (*Viola odorata*).

There is considerable tendency toward individual variability in the venation of the wings of this pretty species.

Genus **PENTALONIA** Coquerel, 1859:259

Antennae six-segmented in both alatae and apterae, sensoria subcircular, frontal tubercles well developed; cornicles elongate, subcylindrical or slightly swollen, longer than the constricted cauda; anal plate rounded; fore wings with a closed cell between

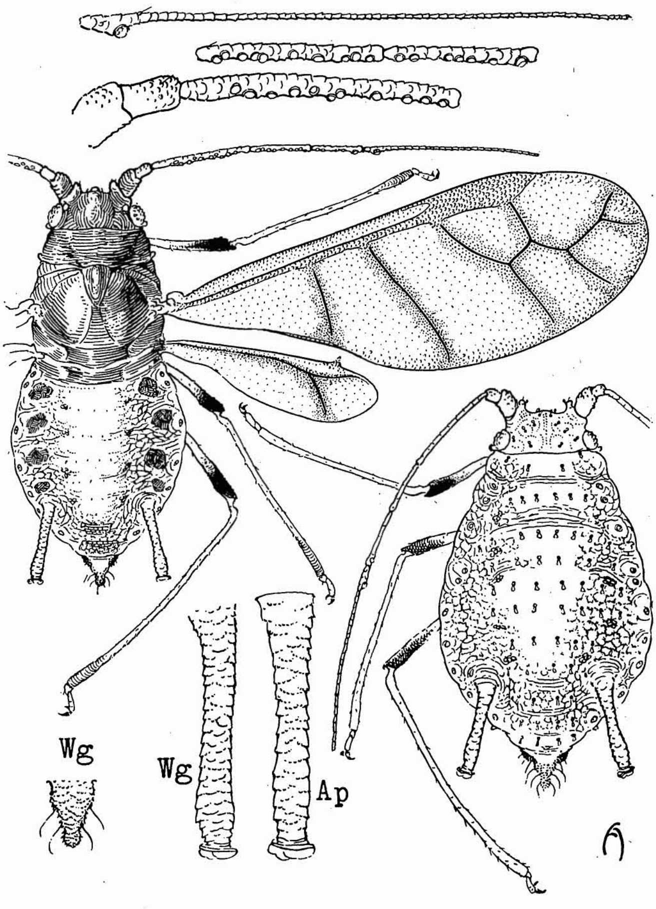


Figure 78—*Pentalonia nigronervosa* Coquerel. The banana aphid. (Drawn by Abernathy.)

stigma caused by the abnormal course of Rs which is fused with M (see illustration), thus making M appear to have three forks, hind wings with M only; body setae in apterae conspicuous and capitate.

The unusual venation will serve to distinguish easily this genus from any other in Hawaii. The membrane along the veins is conspicuously darkened.

Pentalonia nigronervosa Coquerel (fig. 78).

Pentalonia nigronervosa Coquerel, 1859:260, pl. 6, figs. 3, 3a,b. Genotype.

The banana aphid.

Kauai, Oahu, Hawaii.

Immigrant. A widespread aphid which was first recorded from Hawaii by Timberlake (1924:459) from specimens taken in Honolulu, although it was previously known here as an undetermined species.

Hostplants: *Alpinia purpurata,* "ape" taro, bananas (various varieties), "ferns," *Heliconia,* kahili ginger, taro, tomato, torch ginger, *Zingiber.*

Genus **IDIOPTERUS** Davis, 1909:198

Fullawayella Del Guercio, 1911.

See notes by Essig, 1935:156.

Antennae six-segmented in both alatae and apterae, the sensoria subcircular; frontal tubercles strongly developed; cornicles elongate, subcylindrical, tapering, longer than the tapering cauda; anal plate rounded; fore wings with Rs following an abnormal course and nearly fused with M as illustrated, M normally with two forks, hind wings with M and Cu present, although Cu may be somewhat obscure; body hairs conspicuous and strongly developed, those on the apterae mostly occurring in pairs on tubercles and heavily capitate.

This genus is close to *Pentalonia,* and as in it and *Micromyzus* the membrane along the veins is darkened.

Idiopterus nephrelepidis Davis (fig. 79).

Idiopterus nephrelepidis Davis, 1909: 199, pl. 20, figs. 1–8. Genotype.

Idiopterus nephrolepidis, of authors.

Macrosiphum kirkaldyi Fullaway, 1910:22, figs. 1–2 (described from Honolulu).

The fern aphid.

Oahu, Maui, Hawaii.

Immigrant. A widespread species first found in the Hawaiian Islands by Fullaway in the vicinity of Honolulu and described by him, as indicated above, in 1910.

Hostplants: *Elaphoglossum reticulatum, Asplenium kaulfussii, Polypodium lineare.*

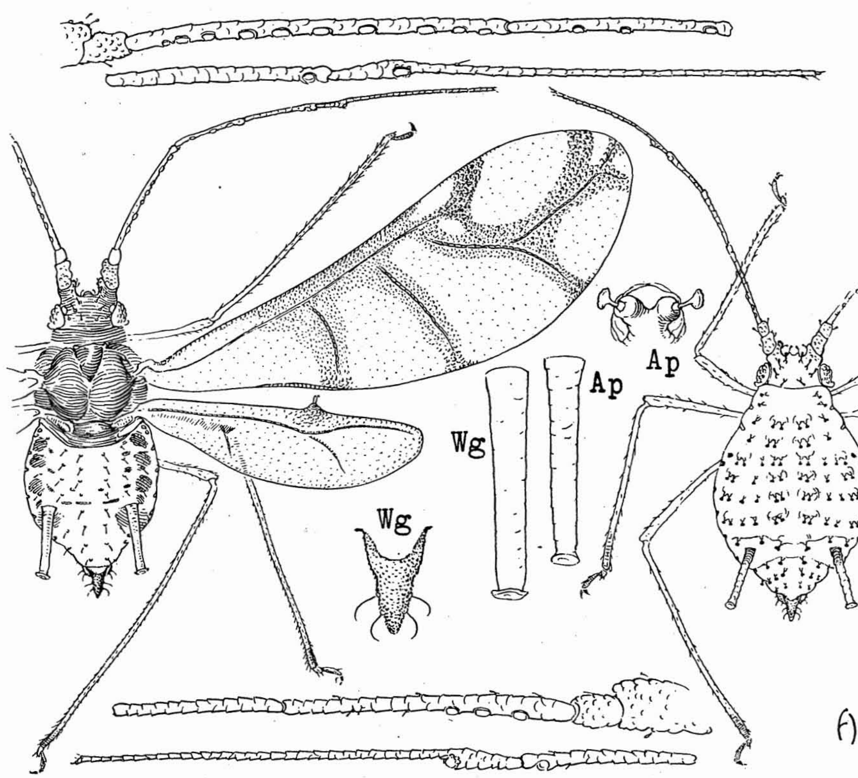


Figure 79—*Idiopterus nephrelepidis* Davis. The fern aphid. (Drawn by Abernathy.)

When Fullaway originally described this species as a new *Macrosiphum* from Honolulu, he evidently figured an abnormal individual which had M in the fore wings with only one branch instead of the normal form which has two branches. As in *Pentalonia,* there is considerable variation in the wing venation of this species.

This species has taken to the mountains where it is found occasionally to be common on various kinds of ferns. I have collected it at about 10,000 feet on Maui. It is much more widespread than our present records indicate.

Subfamily ERIOSOMATINAE

Tribe ERIOSOMATINI

Genus **ERIOSOMA** Leach, 1818

Antennae six-segmented in alatae and apterae (in the "summer viviparae" found in Hawaii), sensoria prominent, transverse and ring-like, last segment without a long filament; cornicles reduced to mere rings; wax glands conspicuous; cauda

short and broadly rounded, anal plate rounded; fore wings with a single branch to M, hind wings with M and Cu present; body hairs short, pointed, inconspicuous.

In our fauna this is a distinctive group which cannot be confused with any other.

Eriosoma lanigera (Hausmann) (fig. 80).

Aphis lanigera Hausmann, 1802:440.

Aphis mali Samouelle, 1819:232.

The wooly apple aphid.

Hawaii.

Immigrant. A widespread, well-known species first recorded from the Hawaiian Islands by Fullaway in 1910 (p. 44) from specimens collected by J. E. Higgins at Waiki, Hawaii, 4,500-foot elevation.

Hostplant: apple.

This species is restricted to certain high elevations on the island of Hawaii where some apple trees have been growing for many years. It is recorded from time to time from the same locality.

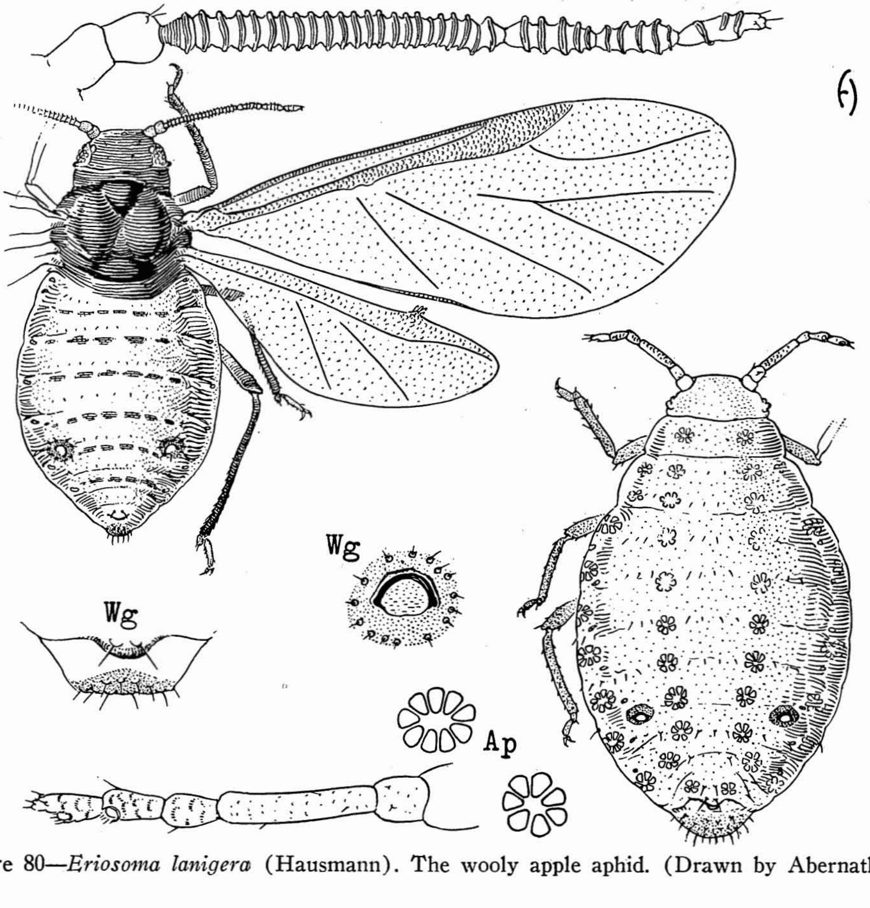


Figure 80—*Eriosoma lanigera* (Hausmann). The wooly apple aphid. (Drawn by Abernathy.)

Subfamily HORMAPHINAE

Genus CERATAPHIS Lichtenstein, 1882

Antennae five-segmented in the alatae, four- or five-segmented in the apterae, terminal segment without a long style, sensoria on alate antennae transverse, annular; frontal tubercles obsolete; nymphs characteristically aleyrodid-like in form, as illustrated, with two peculiar, median, horn-like protuberances on the vertex of the head, and the eyes are reduced to about three facets; wax glands prominent; cornicles reduced to mere rings; cauda transverse and knobbed; anal plate bilobed; fore wings with one fork to M, M and Cu present in hind wings; body hairs inconspicuous.

Cerataphis lataniae (Boisduval) (figs. 81, 82).

Coccus lataniae Boisduval, Ent. Horticole, p. 355, 1867 (I have not seen this reference).

The palm aphid; latania aphid.

Oahu.

Immigrant. Almost cosmopolitan. First recorded from the Hawaiian Islands by Fullaway (1910:45) from specimens taken earlier at Honolulu by Kirkaldy and Van Dine.

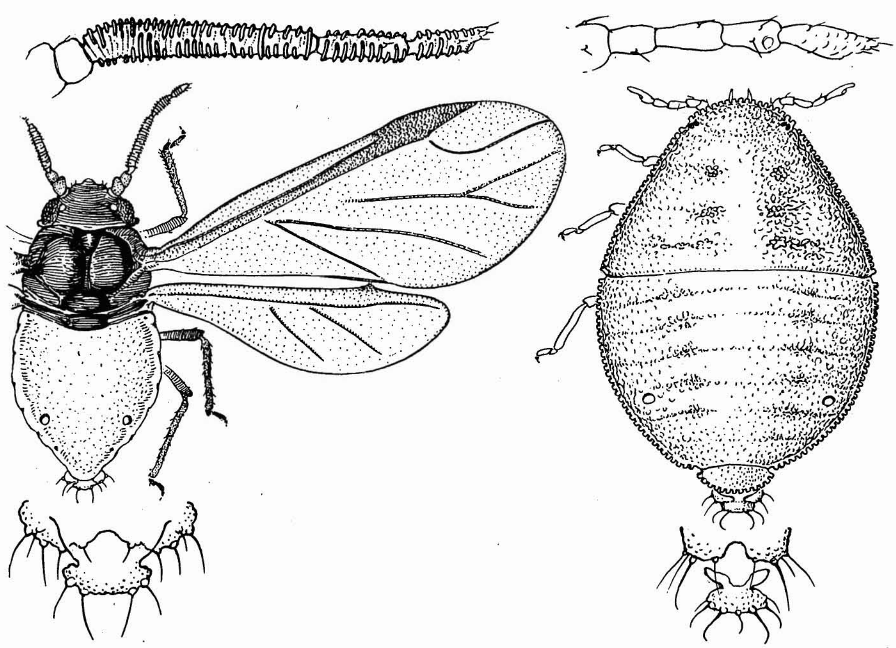


Figure 81—*Cerataphis lataniae* (Boisduval). The palm or latania aphid. (Drawn by Abernathy.)

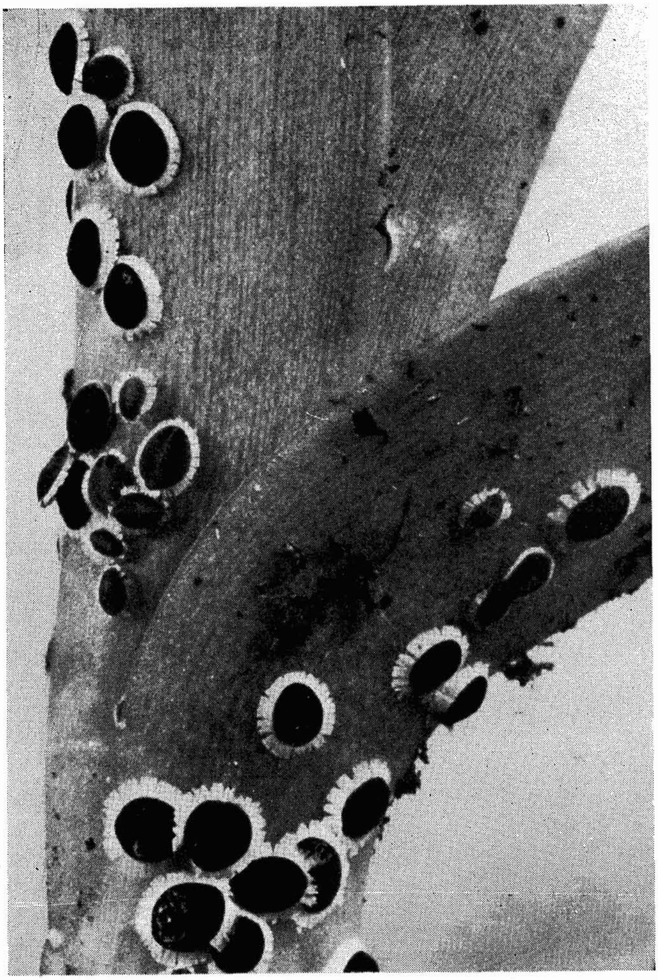


Figure 82—*Cerataphis lataniae* (Boisduval), the palm aphid, on *Epidendrum* orchid. This colony of nymphs was completely covered with debris by *Pheidole megacephala* ants. The "ant shed" has been removed, but some of the remaining detritus can be seen adhering to the plant.

Hostplants: *Pritchardia* (fan palm), orchids.

This is a distinct and characteristic species, and once seen is not easily forgotten. The early stages are beautiful and easily confused with coccids as will be demonstrated by an examination of the illustration. It is the worst aphid pest of orchids in the islands. A weak solution of nicotine in oil is recommended for control.

Genus **THORACAPHIS** Van der Goot, 1917

Antennae (in our representative of the genus) five-segmented in the alatae, three-segmented in the apterous viviparous forms and four-segmented in the nymphs of

the alatae, terminal segment without a long style, sensoria on alates prominent, annular; frontal tubercles obsolete; adult apterous, viviparous females peculiar, aleyrodid-like, coarsely reticulated, immobile creatures, as illustrated; cornicles low and greatly reduced; cauda transverse; anal plate bilobed; fore wings with one fork to M, M and Cu present in hind wings; some body hairs prominent.

Thoracaphis fici (Takahashi) (figs. 83, 84, 85).

Astegopteryx fici Takahashi, 1923:55, pl. 6, figs. 10–13. (Described from *Ficus retusa* and *Ficus wichtiana* from Formosa. "The winged forms are very rare, appearing from January to March.") 1924:96, pl. 4, B, fig. 4; pl. 5, figs. 3–7. (Describes immature forms of winged phase.) 1927:148. (Records it from Macao, China.)

Thoracaphis fici (Takahashi) Takahashi, 1931:92. (Recorded from the Ryukyu (Loochoo) Islands and Botel Tobago.)

The banyan aphid.

Kauai, Oahu.

Immigrant. An Oriental species, now known from South China, Formosa, Botel Tobago and the Ryukyu Islands. It was first collected in the Hawaiian Islands before 1910 by Perkins and was recorded first in our literature by Fullaway (*Proc.*

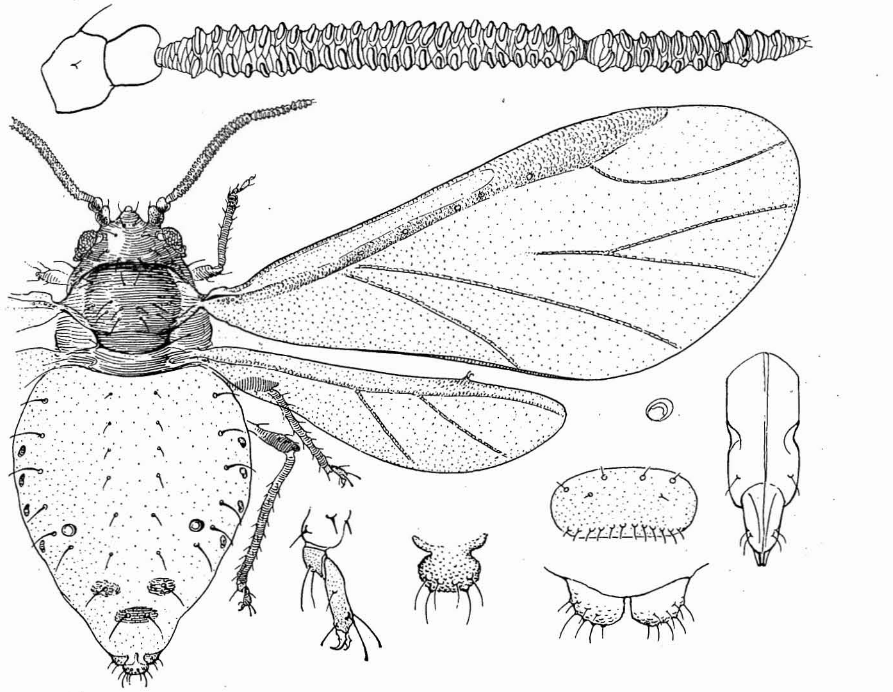


Figure 83—*Thoracaphis fici* (Takahashi). The banyan aphid. Details of winged, viviparous female. (Drawn by Abernathy for this text through the courtesy of E. O. Essig and the Division of Entomology, University of California.)

Hawaiian Ent. Soc. 4 (3) : 471, 1921) from specimens collected in Honolulu by Van der Goot, the aphidologist. It has appeared in our literature under the following names: *Cerataphis fici, Thoracaphis ficus* Baker, and *Thoracaphis fici* Van der Goot. Van der Goot applied the latter name to it when he collected it while passing through Honolulu, but he never published a description of the species.

Hostplants: *Ficus bengalensis, Ficus retusa.*

Predator: *Coelophora pupillata* (Swartz) (Coleoptera: Coccinellidae).

This species occurs in great numbers on the undersides of the banyan leaves, and its black, pupa-like, aleyrodid-like stage is conspicuous throughout the year. Only the aleyrodid-like form was known in Hawaii until I found the nymphs and the mobile viviparous apterae on *Ficus bengalensis* in January and February, 1945, and Jensen and I discovered the winged stages in January, 1946.

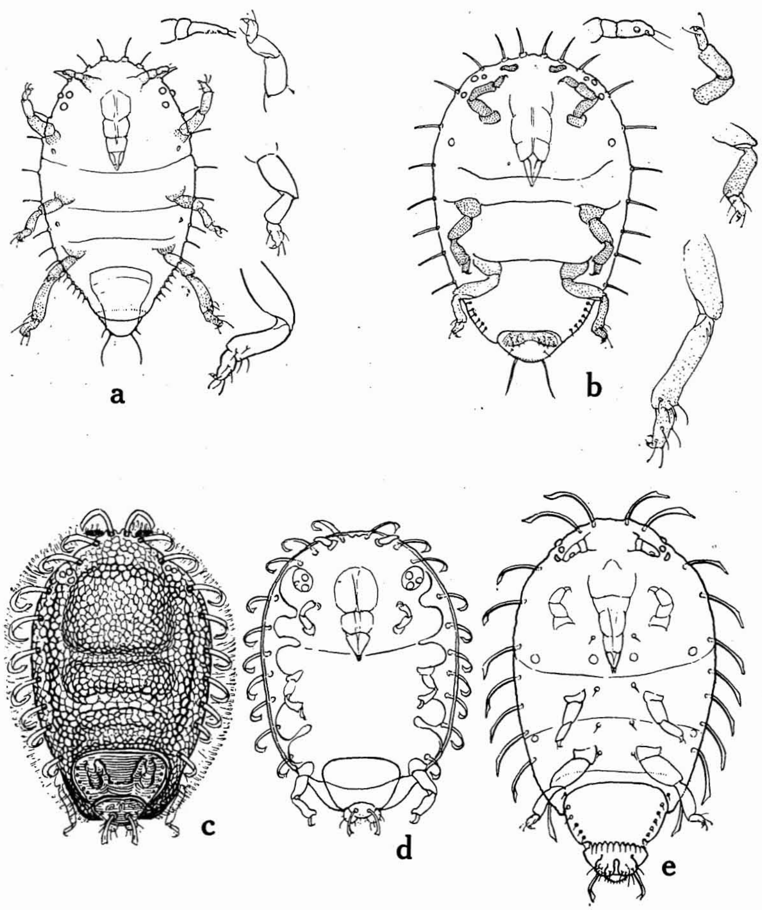


Figure 84—*Thoracaphis fici* (Takahashi). The banyan aphid. Details of the apterous, aleyrodid-like female. **a,** first instar nymph, ventral view; **b,** last instar nymph ventral view; **c,** adult female, dorsal view; **d,** adult female, ventral view; **e,** adult female, ventral view, with wax removed. (Drawings made for this text by Abernathy through the courtesy of E. O. Essig and the Division of Entomology, University of California.)

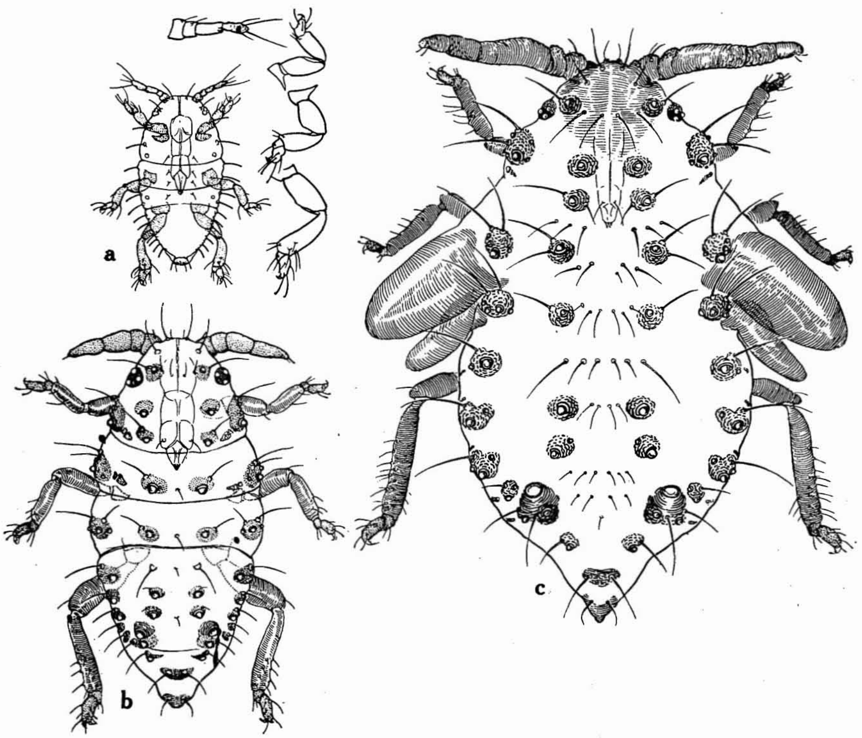


Figure 85—*Thoracaphis fici* (Takahashi). The banyan aphid. Details of immature stages of the winged female. **a,** first instar nymph; **b,** intermediate stage nymph; **c,** last stage nymph. (Drawn for this text by Abernathy through the courtesy of E. O. Essig and the Division of Entomology, University of California.)

The first-stage nymphs are about 0.25 to 0.30 mm. in length, are greenish, yellowish or yellow in color and have a marginal or submarginal fringe of conspicuous, hair-like setae around the body; the antennae also have long hairs.

These crawlers are active and roam about on the leaves until they find a suitable place for settling down. After becoming situated, and after several molts, the ultimate, immobile, aleyrodid-like stage is attained. This is, as is *Cerataphis,* a strikingly un-aphid-like form. It assumes a black, hard, shell-like, coarsely reticulated form with the sides fringed with conspicuous white wax filaments. The only indications that the creature is alive are the occasional uplifting of an anal plate and the expulsion from the anus of a globule of honeydew by its being flicked off in a manner similar to that employed by the aleyrodids.

From the black, pupa-like case emerge young crawlers, mostly the first-stage nymphs described above, but in the winter there also arises a distinct form which leads to active, winged, viviparous females. The young of these are grayish-green in color and have a tuberculate dorsum. From the dorsal tubercles are produced very long, aleyrodid-like wax filaments. Instead of becoming immobile, these forms remain active; as they grow they become clothed with a thin powdery wax that gives them a grayish appearance and through which the tubercles show as dark spots.

The winged females which arise from these nymphs are (for our fauna) peculiar, slow-moving aphids. The wings are held out flat, obliquely from the body and not roof-like as in most of our aphids. I have been unsuccessful in my attempts to make them fly. Even if dropped, they do not fly, but flutter down to earth. The body is black with a greenish tinge, and the annular sensoria on the antennae are very prominent. In spite of repeated and careful search only a few of these winged females have been discovered at large on the host trees, and most, if not all, of the specimens caught on the trees were teneral individuals. After a prolonged and unsuccessful search, the first winged forms were obtained by placing cloth sleeves over infested leaves. Subsequently, additional females were reared in jars in the laboratory. It appears that the winged females leave the host leaves soon after emerging, but when and whence they go remains an unsolved problem. I dissected one example and found the abdomen packed with 20 embryonic nymphs. The season for the winged forms in Honolulu is late December, January and early February; I have found only a few nymphs of the winged forms as late as the early part of March.

Superfamily COCCOIDEA Handlirsch, 1903

Coccidae Fallen, 1814, and other authors.
Coccidoidea, of authors.

Scales, Coccids, Mealybugs

This group includes the most evolved and specialized forms of the order Hemiptera. It is one of the groups of insects most destructive to agriculture. Some species furnish useful products well known in international commerce, such as shellac (from *Laccifer lacca*), cochineal red (from *Dactylopius coccus*), crimson lake, and other dyes; some species produce in abundance wax of marketable value, such as Chinese wax (from *Ericerus pe-la*), which is used for candles; some species of *Margarodes* have hard, lustrous shells which are fashioned into jewelry; and the manna of the ancients, still used today, is a coccid excretion. The group is one of the most taxonomically difficult of all insects. The pertinent literature is voluminous.

Minute to medium-sized insects (mostly small, but certain Australian and African species reach a length of more than an inch; at least one African species attains a length of 35 mm.—one and three-eighths inches), mostly soft-bodied, many covered with a shell or scale, adult females mostly immobile. Sexually dimorphic, the sexes so different as to appear to belong to different orders. Females always wingless, males usually winged, but apterous in some forms. Reproduction bisexual, or, as in many species, parthenogenetic, some hermaphroditic, oviparous or ovoviviparous. First-stage nymphal forms (crawlers) active, and apparently alike in the two sexes. Adult females mobile or sedentary; compound eyes reduced to a single lens or wanting; antennae vestigial or from one- to 11-segmented; rostrum short, one- to three-segmented, stylets thread-like, coiled within the body when at rest; legs either wanting, rudimentary, reduced or fully formed and used for locomotion, tarsi one-segmented (two-segmented in some female Margarodidae), claws single, sometimes reduced or obsolete, body segmentation distinct, obscure or indistinguishable; secreting either waxy or cottony coverings or ornamentation, or with a hardened derm that forms a shell, or producing a protecting scale beneath which it lives; many forms incapable of locomotion after the first molt; the derm with a varying array of greatly specialized gland openings, pores, ducts, tubes, fringes and other modifications and specializations. Males (poorly known to science) small to minute, always smaller than the females, with two nymphal instars, the second a pupal form; adults with a variable number of ocular facets, or with compound eyes; mouth parts atrophied; antennae long, often 10-segmented; with well-developed legs; if winged, with one pair of delicate wings which have at most only two prominent veins

(R and M), and which are folded flat over the abdomen when at rest, the hind pair represented by halteres which attach to the fore wings by means of hooks; the abdomen usually terminates in a spine-like genital process and may or may not have long, delicate, filamentous processes; the male scale or "cocoon" is usually conspicuously different from that of the female.

This group is so diverse in habit and form that it is difficult to outline its various types in one place. Reference should be made to the discussions of the families hereinafter, and all students are referred to the standard textbooks for more detailed information.

The scale insects attack all parts of plants from roots to buds, flowers and fruits. Some are subterranean in habit. Some forms produce honeydew in great abundance, whereas others, particularly the Diaspididae, do not produce the sweet excretion. Some forms cause galls to form on their hosts, others cause leaf-rolling, surface-pitting or other tissue changes. Some are vectors of plant diseases, or they cause disease symptoms by injecting irritating salivary products into plant tissues.

Dispersal of coccids depends mostly upon two principal means of movement. Inasmuch as all the females are wingless, and a large number of them are sedentary or legless when adult, it is the active young or "crawlers" which move about from one part of a plant to another or from plant to plant. However, certain females are capable of migrating. Their dispersal over any considerable distance is due mostly to their being blown about by the wind. They are also carried by birds, according to Ferris. Some species are provided with hairs which aid in their dispersal as down aids in dispersal of the seeds of many composite plants.

The coccids reach their greatest development in the tropics and semitropical regions. The most peculiar forms, as well as some of the largest species, live in the Australian region. They are poorly represented in the endemic Polynesian faunas, but Hawaii has a peculiar, native development in the Pseudococcidae.

Franz Schrader and Sally Hughes-Schrader have written many papers in recent years on cytology, chromosomes, spermatogenesis, parthenogenesis, hermaphroditism and related subjects which are of interest and value to the serious student. See the quotation from one of Mrs. Hughes-Schrader's papers under *Icerya purchasi* on page 138.

The control of coccids varies with the group involved and the crop attacked. In Hawaii, through the use of imported ladybird beetles and parasitic wasps, we have had remarkable success with biological control, but a few species have not yet yielded to control by natural means. Early reports give vivid descriptions of the almost unbelievable numbers of various species of scale insects attacking plants and the great damage they caused in Hawaii before the introduction of predators and parasites. It is obvious that the overall coccid problem is today a comparatively minor one as compared with that existing before 1900, with the exception of the control of the pineapple mealybug. Chemical control is necessarily different in certain respects in Hawaii from that employed in temperate regions. We do not have a dormant season here when temperate-zone deciduous trees are free from foliage and when strong oil emulsion sprays can be used without injury to the plants. Most of

our plants are in foliage the year round, and special care must be used in the choice and application of spray materials. There is no sure-cure, overall spray material to recommend for use in the islands. Various kinds of scales succumb more readily to one preparation than to another, and the preparation used for one hostplant may not be safe to use on another. Hence, suggested methods of control are given in the following text under the various species that cause damage severe enough to warrant the use of chemical control measures. The Diesel oil–bentonite emulsions, in dilutions of 1 percent to 4 percent, have been used with marked success on certain pseudococcids, coccids and diaspids, and more research with these economical sprays is recommended. There is, however, one overall recommendation that can be made; inasmuch as ants tend various coccids, transfer them from place to place, protect them and make it difficult for parasites and predators to act efficiently, it is always advisable to control the attending ants to give the natural enemies more opportunity for attack. Individual trees or plants may be ringed with "tanglefoot" to keep ants off them, and ant control in garden and orchard is recommended.

This section has been a difficult and laborious one to assemble. The mass of records pertaining to the local species is in a muddle. It would have been much easier, and perhaps not as illogical as it sounds, to start anew with a Hawaiian coccid survey rather than to go back and apply the earlier published data to the names used herein. Poorly prepared material, almost impossible to work with, added to the confusion. Much misnaming has occurred. Fortunately, Professor G. F. Ferris and Dr. Harold Morrison have come to my aid and have patiently answered many questions and checked a large amount of material which I have collected and sent to them. The form in which this section is now presented reflects their generous cooperation.

Dr. Morrison has accepted for identification series of specimens which I have sent to him over a period of years and has returned identifications and notes promptly. He read the manuscript in detail and discussed it page by page with me in Washington, D. C. He has strengthened the work materially. I owe him many thanks.

Professor Ferris' contributions to this work have been unique. I cannot express adequately my indebtedness to him for his great interest, comments, advice, collaboration and, above all, his brilliantly executed illustrations—many made especially for this work. The readers will render him due credit whenever they use this chapter of *Insects of Hawaii*. His efforts will make the work of the student less laborious and more accurate.

Professor Ferris has taken a special interest in the Kermidae, Coccidae and Pseudococcidae and has added much to my original manuscript on these sections.

Howard McKenzie also read the manuscript, with particular attention to the Diaspididae, and I take this opportunity to thank him.

It will be obvious to the reader that the host and distribution records for most of our coccids are incomplete and inadequate. Moreover, many species are probably established in the islands which have not yet been recorded; a number are known to

me. This fact should be a challenge to those who have opportunities to collect and record new data on the group.

In spite of long and careful collecting in the Hawaiian Islands, no native scales belonging to the Margarodidae, Ortheziidae, Coccidae, Asterolecaniidae, Kermidae and Diaspididae have been found here. I believe that these families are absent from the endemic fauna. On the other hand, we do have a well-developed, but little-known, endemic assemblage of Pseudococcidae. Not a few of our native Pseudococcidae are among the more unusual of the known species of the family.

Key to the Families of Coccoidea Known to Occur in Hawaii

(For slide-mounted specimens.)

1. Abdominal spiracles present (two or more pairs) 2
   Abdominal spiracles absent 3

2(1). Anal ring without setae .... **Margarodidae.**
   Anal ring setigerous .... **Ortheziidae.**

3(1). Dorsal ostioles present (except *Phyllococcus*) .... **Pseudococcidae.**
   Dorsal ostioles absent 4

4(3). Anal opening covered by a pair of plates which form an operculum .... **Coccidae.**
   Anal opening without such plates 5

5(4). Lateral margin of body with numerous 8-shaped wax gland pores .... **Asterolecaniidae.**
   Lateral margin of body without well-developed 8-shaped pores 6

6(5). Anal ring not setigerous .... **Diaspididae.**
   Anal ring setigerous 7

7(6). Anal lobes and preceding three abdominal segments sclerotized and forming a conspicuous dorsal plate; tubular ducts wanting; peculiar, gall-inhabiting species. *Phyllococcus* of the .... **Pseudococcidae.**
   Only the anal lobes sclerotized and produced; tubular ducts present, all with inner extremity reflexed to form a deep cup from the rim of which arises a filamentous prolongation .... **Kermidae.**

Family **MARGARODIDAE** (Newstead, 1901) Morrison, 1927

The Giant Coccids

A single widespread pest species is the only representative of this family in Hawaii. Its large size and characteristic appearance (fig. 86) distinguish it from our other coccids. The diagnostic features displayed in slide-mounted specimens are the presence of thoracic and abdominal spiracles in combination with a non-setose anal ring. For a detailed study of the family, see Morrison, 1928.

Subfamily MONOPHLEBINAE Maskell, 1895

Tribe ICERYINI Cockerell, 1899

Genus **ICERYA** Signoret, 1875

This is the largest genus of the subfamily, and it has a pan-tropical distribution with extensions into the lower temperate regions.

Icerya purchasi Maskell (fig. 86).
Icerya purchasi Maskell, 1878:221, pl. 8, figs. 20, 21.

The cottony cushion scale.
Kauai, Oahu, Molokai, Maui, Hawaii.
Immigrant. An Australasian species which has become widespread by commerce. The earliest record I have seen for Hawaii in entomological literature is that by Maskell, 1894:30, but the species was established in Hawaii long before that date.
Hostplants: *Acacia, Cassia glauca, Casuarina, Citrus, Desmanthus virgatus, Desmodium canum, Desmodium uncinatum, Gossypium tomentosum,* lime, monkeypod, *Nothopanax,* peppermint, rose, sage, silver wattle, *Sophora chrysophylla* ("mamani").
Predator: *Rodolia cardinalis* (Mulsant) (Coleoptera: Coccinellidae) (also known as *Vedalia, Novius,* the "Vedalia") is an efficient predator. It was introduced from Australia to California in 1888 by Albert Koebele to prey upon the cottony cushion scale which was threatening the citrus industry there with destruction. The remarkable success in the control of the scale is one of the high marks of applied entomology and was the first successful introduction of a beneficial insect from one place to

control a pest species in another area. Its introduction to California thus marks the beginning of biological control work in entomology. This led to Koebele's employment by the Hawaiian government to continue his work for the good of the islands.

In 1890 the Vedalia was introduced to Hawaii from California by Koebele. Perkins (1897:499) noted that:

> At that time many trees were in a deplorable condition from the attacks of *Icerya,* the monkey-pod trees being particularly badly infested—so much so that they were being largely cut down, as the only resource. The *Vedalia* was a complete success; it became perfectly naturalised, increased prodigiously for a time, practically cleared the trees, and then, as the *Icerya* became comparatively scarce, decreased in numbers; while at the present time it is evident that the number of the scale and its destroyer has arrived at a fixed proportion.

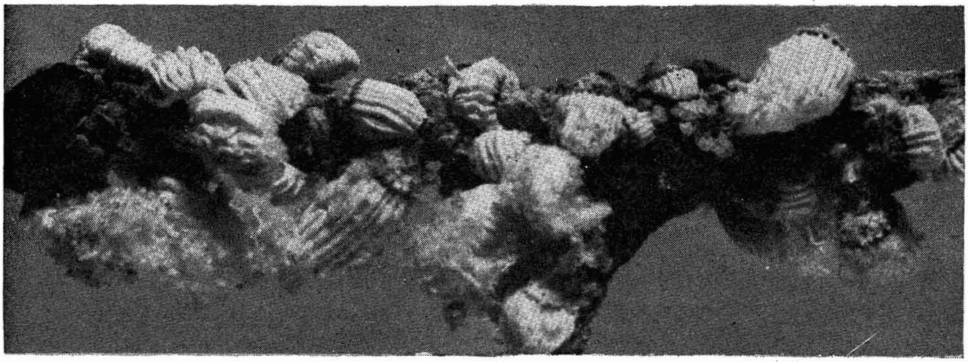


Figure 86—*Icerya purchasi* Maskell. The cottony cushion scale on a *Cassia glauca* twig.

Today, 55 years after the predator's introduction, the scale is still held in control as Perkins described in 1897. Infestations of monkey-pod trees today are uncommon and usually consist of small colonies.

This successful control project recalls the case of *Eriococcus coriaceus* Maskell, which is an Australian *Eucalyptus*-infesting species. In its native area it does little damage. However, it was accidentally imported to New Zealand where it immediately became a serious pest and killed off "many thousands of acres of Blue Gum." The introduction of a *Rhizobius* brought it under satisfactory control.

The red and black, hairy *Vedalia* lays its bright-red eggs on the eggsac of the scale. The young, pinkish larvae make their way into the eggsac, where they feed greedily on the eggs and young of the scale.

The cottony cushion scale cannot be confused with any other scale insect now found in Hawaii. Its large size (up to about 10 mm. in entire length), fluted ovisac and general appearance (see fig. 86) will serve to distinguish it. When the white ovisac is fully formed, it forces the body of the scale upward so that the scale appears to be standing on its head with the fluted white sac trailing behind. The body of the scale proper is red, yellow and brown, with some variation. The bright-red eggs are produced in masses and may be found easily by breaking open the eggsac. It is said that a single female may lay from 400 to 1,000 eggs. The crawlers are red. The

males form white cocoons soon after hatching and emerge a few weeks later as delicate, red-bodied, dark-winged creatures. The females develop more slowly.

Detailed information on the bionomics of this common scale under Hawaiian conditions is not available. When it is not controlled it develops in prodigious numbers, clothes the hostplants in enormous masses, and may cause severe damage or death to the hosts.

For an account of the mating habits of the species, see Shinji, 1917:162, and Hughes-Schrader, 1930:361. The latter reference contains a detailed study of development, a section of which is considered worthy of quotation here as an example of the intriguing problems open to critical students, and as an example of the diversity of structure and habit in the coccids.

Mrs. Hughes-Schrader (1930:363–364) reports that:

all of the so-called females of *Icerya purchasi* are in reality hermaphrodites capable of the self-fertilization of their own eggs by their own sperm. Copulation may indeed occur between these hermaphrodites and the occasional males, but it is in no wise necessary for reproduction. Cytological study shows that the hermaphrodites are always diploid in chromosome constitution while the males are haploid. The diploid chromosome number is four, and the haploid two; in both sexes the cytological conditions are exceptionally clear and convincing. The hermaphroditic gonad is basically an ovary. During development the right and left gonads meet and fuse anteriorly dorsal to the gut thus forming a horseshoe shaped structure whose posterior ends terminate in short ducts. The fusion of these ducts posteriorly forms a heavy walled glandular vagina which leads to the external genital aperture. At the point of junction of the ducts there may occur a small thin walled blind diverticulum, the spermatheca, as described by Johnston ('12); but this may be entirely absent as stated in my 1925 study. Since that time I also have found it present in certain specimens, and believe it to be of rather general although variable occurrence. In the majority of coccids the ovaries are hollow structures with the eggs forming in pouches or ovarioles from their walls. In *Icerya purchasi* however the hermaphroditic gonad is solid during the early instars. In the first instar certain of the centrally lying cells become reduced to the haploid condition, and these haploid cells, proliferating rapidly, come to form a solid central core in the gonad. The outer cells remain diploid and from them the ovarioles with their oocytes and nurse cells, the follicular and interstitial tissue are all derived. The haploid cells give rise to sperm. As the sperm mature they become twisted into tight bundles; the bundles are coiled and come to lie freely in the central cavity of the gonad. The gonad is thus actually hollowed out by the process of sperm formation. From the outer walls of the gonad meanwhile normal ovarioles are developing in which the eggs come to maturity. All eggs undergo two normal maturation divisions, in which the chromosomes are reduced to the haploid condition. If these eggs are fertilized by sperm, diploid embryos are produced which always give rise to hermaphrodites. If the eggs remain unfertilized, they develop parthenogenetically into haploid males. Fertilization of the eggs of the hermaphrodite by its own sperm has been demonstrated cytologically in a large series of hermaphrodites which were held in complete isolation from males.

Since the hermaphrodite produces ripe sperm in large numbers before the period when copulation with a male is possible, one cannot determine with certainty whether the sperm of the males are also potent. Copulation does not affect the parthenogenetic production of males; extended breeding experiments have shown that males are produced in varying numbers indifferently by both hermaphrodites which have mated with males and those which have been completely isolated from males. Thus from 31 hermaphrodites which had mated with males 2,548 hermaphrodites and 39 males were produced; while 10 hermaphrodites isolated from males gave rise to 1,616 hermaphrodites and 5 males.

Family **ORTHEZIIDAE** (Green, 1896) Enderlein, 1920

The Ensign Coccids

This is a Holarctic and American family. In Hawaii it is represented by one widespread species. Like *Icerya* in the Margarodidae, the single local representative is easily recognized by the salient features illustrated. The legs and antennae are remarkably long, proportionately, as compared to those of our other coccids, and they protrude far beyond the front and sides of the body. The females are quite active and can move about readily. The long, narrow, fluted, white ovisac is held in a somewhat elevated manner, hence the common name, ensign coccids. Thoracic and abdominal spiracles are present and the anal ring is setigerous.

This group was revised by Morrison (1925:97).

Subfamily ORTHEZIINAE

Tribe ORTHEZIINI

Genus **ORTHEZIA** Bosc, 1784

Orthezia insignis Browne (fig. 87).

Orthezia insignis Browne, 1887:169, fig. 2.

Orthezia insignis Douglas, 1888:169, figs. 1–4.

Morrison, 1925:123, figs. 3,J; 5,K; 17; pl. 1, H; redescription. Zimmerman, 1946:657, notes on authorship.

The greenhouse orthezia.

Oahu, Maui, Hawaii.

Immigrant. A tropical American insect first described from specimens taken from plants in a greenhouse at Kew Gardens, England, and now widely dispersed over the world. First found in Hawaii by Brother Frank of the Catholic Mission at Wailuku, Maui, in 1899; later in the same year it was noticed by G. P. Wilder, who brought it to the attention of local agricultural authorities. Some persons have believed that the insect was purposely introduced by Koebele to control lantana, but this belief is erroneous.

Hostplants: *Alternanthera, Clermontia, Coleus, Eupatorium glandulosum* ("pamakani"), *Gardenia, Hemigraphis colorata,* lantana, *Meyeria, Salvia, Strobilanthes dyerianus.*

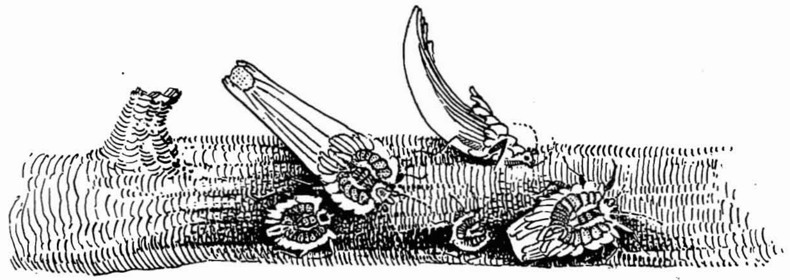


Figure 87—*Orthezia insignis* Browne, the greenhouse orthezia. (Abernathy drawing.)

Predator: *Hyperaspis jocosa* (Mulsant) (Coleoptera: Coccinellidae), an effective controlling agent introduced by Koebele from Mexico in 1907.

The greenhouse orthezia, or lantana blight, as it has been called in Hawaii, is an easy insect to distinguish in the islands. It crawls actively and well; its body is rather firm; its legs and antennae are unsually long for a coccid (these characteristics not infrequently confuse people into considering them insects other than coccids); the ovisac is longer than the body and of a characteristic shape that is well represented in the illustration. The mature females may measure 5 to 6 mm. in length; the body of the scale proper is dark, and the white wax protuberances around the sides and along the mid-dorsal line, and the subparallel-sided ovisac contrast sharply. The tiny males are dusky green. The ovisac

> contains a vast number of eggs that remain until they have hatched when they [the young nymphs] make their exit through an aperture at its extremity. If one of these egg-cases be broken open, it will generally be found to be filled with eggs and young insects. The eggs at the base of the tube are of a very pale creamy color, having just been laid; while lower down they become bright yellow, orange, and then greenish, and the young insects ready to emerge from the tube are olive green. A wooly secretion fills up the crevices between the eggs. These white appendages are very fragile and easily broken. I found the mature male insects were bred from cocoons found in large numbers under stones amongst leaves and rubbish on the ground. . . . (Koebele, 1903:59–60.)

The greenhouse orthezia has long been known as a pest, and its potential danger to plants in Hawaii was pointed out with great care and much emphasis by Koebele in 1903. Koebele was in Australia when the insect was first noticed on Maui, and when he heard of its establishment, he immediately sent word back to Honolulu to try to have the pest eradicated. It seriously injures or frequently kills its hostplants. The copious amounts of honeydew it produces cause heavy growths of sooty mold to develop and these give an offensive appearance to the attacked plants. The orthezia, however, was looked upon with great favor by cattlemen because of its killing out large areas of lantana which had overrun valuable grazing land. Thus, it obtained the name lantana blight; but it proved successful only in the drier, lowland regions. In fact, its distribution was facilitated by cattle ranchers who spread it from place to place.

Family **PSEUDOCOCCIDAE** (Heymons, 1915)

The Mealybugs

This is a large, complex group and difficult to work with. Mealybugs are among the most destructive of economically important insects. There are species which attack almost all parts of plants from roots to fruits. In spite of this, the group is poorly and inadequately known. There is no general work to support the student in the laborious task of identifying his material. Much of what has been written is confusing and misleading. In short, the mealybugs are in a state of taxonomic chaos. Why the group has been so widely ignored by institutions which should have long ago appropriated ample funds to retain a foremost scholar to monograph its species is almost beyond understanding. The proper identification of a pest species of mealybug might on occasion mean the saving of large sums of money, yet shortsighted policy has resulted in the failure to appropriate the modest stipend necessary for proper study of the mealybugs. It is to be hoped that in the not-too-distant future some skilled biologist will be able to overcome the handicaps and give to science an adequate revision of the mealybugs. It is needed!

In an appeal for the better preparation of material and more accurate and adequate work upon the mealybugs, Ferris (1917:321) stated that it was "no exaggeration to say that of the nearly 100 species of mealybugs and their allies thus far described from North America, including some 35 from California, not more than three or four are recognizable at all on the basis of the existing literature if taken apart from their typical host and their type locality." He also pointed out the confusion that exists in the identification of species and noted that on some type slides containing several specimens he discovered individuals representing several different genera! All workers dealing with this group should read Ferris' article in detail and heed his sound advice.

Most of the mealybugs are active, soft-bodied species not covered by a scale, which have the ovate body clothed with a powdery wax and which are usually highly ornamented with wax filaments and protuberances, or with waxy, felted, or cottony covering; the body segments are usually distinctly defined. Reproduction is either oviparous or ovoviviparous. The first-stage nymphs of our species have six-segmented antennae, insofar as is now known. There are four nymphal instars. The mature females can be distinguished by the development of the vaginal opening. The male nymphs take no food after the first molt, at which time the mouth parts atrophy; they pupate in small cocoons. The adult male is usually winged, but apterous forms are known.

Morphology of the Pseudococcidae

It is not the intention here to enter into an exhaustive discussion of the morphology of the Pseudococcidae but some explanation is necessary since certain terms are

employed here which will not, in general, be familiar. Professor Ferris has kindly drawn up the following outline of morphology.

ANTENNAE

The antennae are of a form that is rather characteristic for the family; this is at times an aid in the placing of genera in which other structures of critical importance have been lost, as is the case with the genus *Phyllococcus*. In some species the antennae are greatly reduced at maturity, but in all they are present in the first instar, and wherever they are definitely developed this characteristic appearance is to be found. It rests upon the fact that usually the first two or three segments are somewhat larger and longer than those immediately succeeding them, while the terminal segment, or at times the two terminal segments together, is elongated, the antenna thus having a slightly clavate appearance.

The number of antennal segments is, at its maximum, nine, which is the characteristic number in *Phenacoccus* and certain related genera. Within limits, the number is of some generic significance, but the old system, in which the genera were based entirely upon this, is quite misleading. Also, within certain broad limits the antennae may have some significance in marking species, but there is a great variability, even between opposite sides of the same specimen—so much so that nothing is to be gained by focusing attention upon them.

THE LEGS

In some forms the legs are reduced or even lacking at maturity, but except for this, the character which is of generic significance is to be found in the claw. In *Phenacoccus* and related genera there is, on the plantar margin of the claw, a little tooth which is quite distinctive and seems to correlate with other characters to such a degree as to make it a very useful taxonomic aid. In some forms it is very small, but usually it is definitely either present or absent, and as it can be seen quite readily it offers a very good key character. There appears to be nothing of significance in the tarsal or claw digitules or in the hairs with flattened apices.

THE SPIRACLES

Only the two thoracic pairs of spiracles are present. In general they offer nothing of taxonomic importance, although in a few extreme forms there are developments of some significance.

THE MOUTH PARTS

While it is evident that there are slight differences in the clypeus and labium of different species, there seems to be nothing sufficiently marked to be usable in taxonomic work.

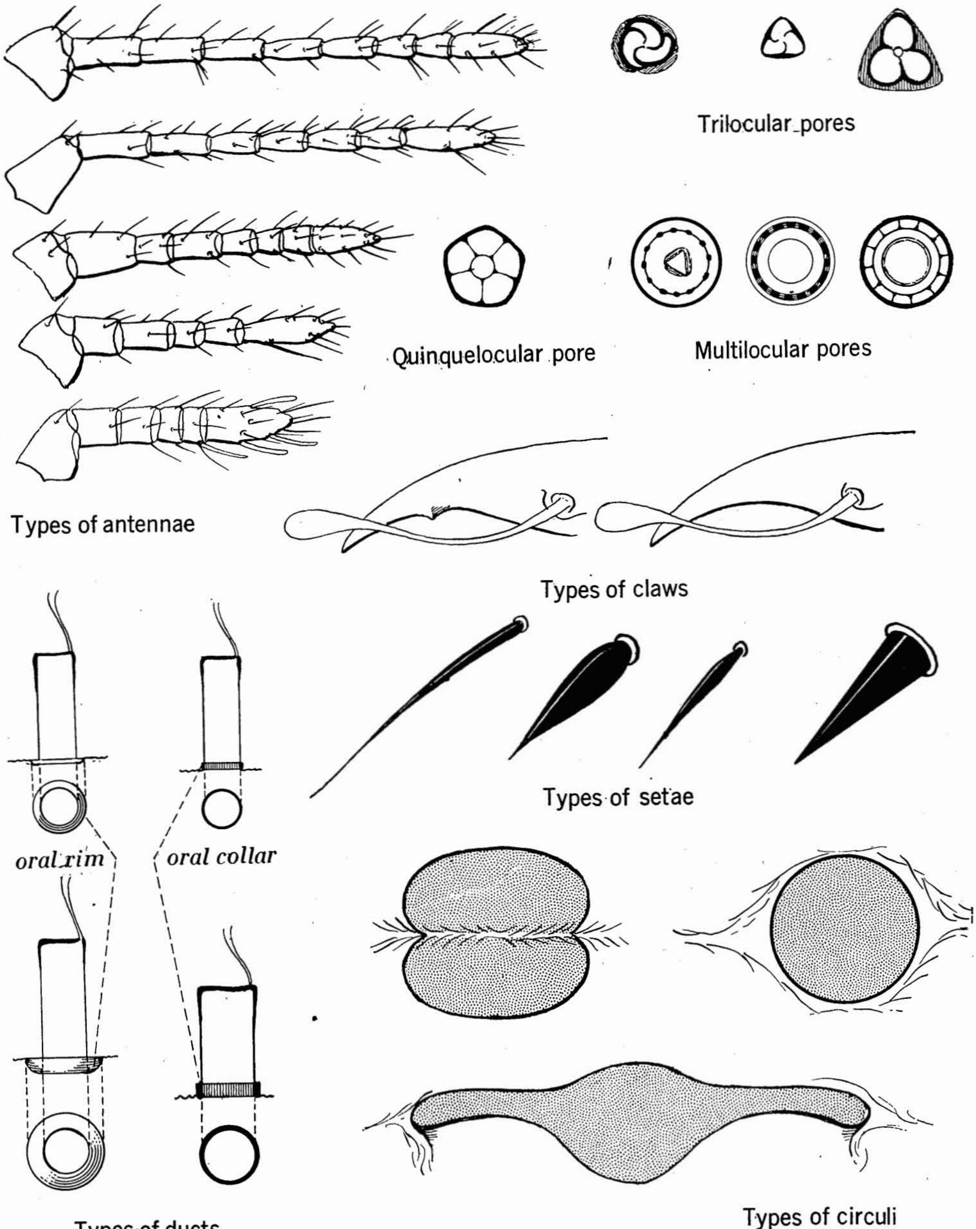


Figure 88—Features of Pseudococcidae. (Drawings by Ferris.)

THE ANAL RING

In general, the anal ring is cellular and bears more or less long setae. In a few forms the number of setae is increased and may be of generic significance. The anal ring is subject to a considerable degree of modification, being much reduced in some species and very much elaborated in others, but among closely related forms it usually offers little or nothing that is of any aid taxonomically.

THE DORSAL OSTIOLES

The dorsal ostioles are one of the characteristic and distinctive features of the Pseudococcidae, so much so that their presence is entirely definitive of the family. It is now clear, however, that there exist species which lack ostioles, but which, on the basis of the totality of their structure, belong to this family. The presence of the ostioles will place a species definitely in this family, but their absence will not exclude it. In the endemic genus *Phyllococcus,* which seems definitely to belong to this family, they are lacking in all stages.

These ostioles are merely slit-like openings, sometimes with a more or less tumid area about them. The anterior pair is on the head and the posterior on the (morphologically) seventh abdominal segment. They open directly into the body cavity and through them drops of body fluid may be expelled.

[They appear as eye-like spots just behind the eyes and in somewhat similar positions near the caudal end of the abdominal dorsum. They are thought by some workers to be similar in function to the pleural ostioles of true bugs, and they recall the cornicles of aphids. Some workers have considered them openings through which glandular products are secreted—presumably of repugnatory nature. However, Ferris and Murdock (1936:115–116) have shown that although the ostioles are openings into the body cavity, no glandular tissues are associated with them. "In life the presence of these ostioles may be demonstrated by stimulating the insect by any application of violence. A globule of liquid, which quickly coagulates or hardens, may thereupon issue from one or more of these openings. The amount of material extruded and the frequency with which extrusion can be induced varies with individual specimens. Some apparently cannot be induced to react at all, while others respond repeatedly." These authors believe that the substance extruded is the body fluid itself, not a glandular or specialized secretion. E.C.Z.]

THE CIRCULUS

On the ventral side of the abdomen, morphologically on or between the third and fourth segments, there appears a structure to which the term "circulus" was applied by Ferris and Murdock. This is associated with what seems to be a gland of internal secretion, but in taxonomic preparations it appears as a ring which encloses a smooth and hairless area. The ring is sclerotized and clearly differentiated from the surrounding derm. The area within the ring tends to become pigmented at full maturity, sometimes being quite melanic. In some forms this circulus extends across the intersegmental line and is transversely broken by that line, along which it can fold.

In others it seems to lie entirely within the third segment and does not cross the intersegmental line. In some forms there may be two or more circuli, and in some these circuli are reduced to what appears like a median row of little buttons.

The presence of the circulus seems to be distinctive of the Pseudococcidae, but structures of somewhat similar appearance but different morphological position occur in certain of the Margarodidae. But, unfortunately, the structure may be lacking in forms which otherwise appear to be Pseudococcidae. In fact it may be present or absent in closely similar species and may afford an excellent specific character. Its significance in generic classification remains to be investigated.

SETAE

The character of the body setae, especially those of the dorsum, is of some generic significance and frequently is specifically distinctive. Certain setae along the margins of the body are usually larger and differentiated in form from those of the remainder of the body and enter into the composition of the cerarii, which will be discussed later.

DUCTS AND PORES

The glands, from which the wax which covers the body and forms the ovisac is secreted, open to the exterior through various types of pores and ducts; as many as five or perhaps even six types appear in a single species. The nature and distribution of these various types of pores and ducts offer some of the most useful—but in general the least known—of the means of specific differentiation. We may here neglect the glands themselves and consider only the structures to be found in dermal preparations.

TRILOCULAR PORES

The type of pore most universally present in the mealybugs is one which is more or less triangular in shape and is divided by partitions into three cells. If any pores at all are present, they will usually include this type. The type is subject to some variation, occasionally losing its triangular form and becoming irregular and at times showing secondary partitions which cause it to become more or less six-celled. In some forms these pores are minute, in others they are extremely large and conspicuous. In some species they are arranged in definite areas, being absent from portions of the derm. When this occurs the insect in life will show areas free from secretion.

MULTILOCULAR DISC PORES

These are circular pores with apparently numerous small peripheral openings. They vary in appearance, perhaps in part because of different degrees of staining, although it is possible that there actually are sub-types. They occur chiefly on the venter of the abdomen about and anterior to the vulva, but at times may be present

even on the dorsum of the body. Their arrangement and distribution are frequently specific characters of much value in identification.

QUINQUELOCULAR OR PENTAGONAL PORES

In some species, especially in the genus *Phenacoccus,* there are present pores of a definitely pentagonal, five-celled type. In one genus, *Heterococcus* [not Hawaiian], these entirely replace the trilocular pores. In *Phenacoccus gossypii* they are present especially on the venter of the thorax and on the head and form part of the set of characters that mark this species.

CIRCULAR PORES

Excessively minute pores of circular form are rather commonly present. They are so small that they can be detected only with high magnification and at present they seem to offer no possibility of use in taxonomy.

TUBULAR DUCTS

Certain glands open through a tubular duct of characteristic form. In general, the duct may be described as an invaginated cylinder, closed at its interior extremity by a transverse wall so that the duct is truncate. From one margin of the internal extremity a minute and delicate prolongation of the tube leads into the lumen of the gland. This filamentous prolongation is frequently destroyed in preparations or cannot be seen, but in well-stained specimens it can usually be detected. These internally truncate ducts with the filament asymmetrically placed are characteristic of the Pseudococcidae. Similar ducts, but with the inner end cup-shaped, occur in, and are distinctive of, other families.

Very commonly the wall of the duct is thickened for a short distance from the orifice; sometimes this thickening is quite conspicuous. It is here referred to as the "oral collar."

At times the duct orifice is surrounded by an elevated rim and very commonly the outer wall of this rim is somewhat sclerotized, so that as the duct is viewed from the end there appear two concentric circles, one of which is the margin of the orifice and the other the outer wall of the elevated rim. These ducts represent a distinct type and their distribution is frequently characteristic of the species.

These ducts, both of the oral rim type and the oral collar type, appear in various sizes, at times as many as four sizes in a species. The distribution of the various sizes and types forms a part of the characteristic pattern of each species.

In a few species, such as *Ferrisiana virgata,* some of these ducts may be enormously enlarged and have the orifice surrounded by a sclerotized area.

THE CERARII

One of the distinctive features of the Pseudococcidae is the occurrence of clusters of pores and setae along the lateral margins of the body, these clusters

having been called "cerarii" (singular "cerarius"). Commonly the cerarian setae are differentiated in size and form from the rest of the body setae; the most frequent arrangement is in a pair. Accompanying this pair there may be slender accessory setae and usually there is at least a slight concentration of trilocular pores about the bases of the cerarian setae. The wax issuing from the trilocular pores accumulates upon the setae and this gives rise to the pencils of wax which are so commonly seen in members of this family.

On the abdomen there is not more than one cerarius at the lateral margin of each segment. The number assignable to the individual parts of the thorax and to the head is not yet definitely determined. The total number of cerarii seems to be basically seventeen or eighteen. When eighteen are present the extra one is interpolated on the head. The number may vary from this down to none at all.

The cerarius of the anal lobes (morphologically the ninth abdominal segment) commonly presents special modifications in the form of an increased number of pores, larger cerarian setae and a surrounding sclerotized area. In some extreme forms, such as the genus *Puto* [not Hawaiian], each cerarius may be surrounded by such a sclerotized plate.

The number and character of these cerarii are among the important characters available for the identification of species and without much doubt they must be considered in attempts at a generic classification. Like all the other structures, however, there are difficulties and their worth in general classification remains still to be evaluated.

THE MALES

Undoubtedly we shall never have a sound generic classification of the Pseudococcidae until the males have been taken into consideration. However, so few males are known at the present time that we have no basis for judgment as to their significance. The study of the males is a distinct problem in itself that remains still to be undertaken.

Of all of the groups of Coccoidea, the mealybugs appear to be the only group which has gained entrance to the Hawaiian Islands by natural means and which has developed an endemic complex within the islands. These difficult-to-work-with insects have largely been ignored by local entomologists, although Ehrhorn did describe a few of them. Evidence now at hand indicates that Hawaii has one of the most distinctive mealybug faunas of any region. The peculiar gall-forming genus *Phyllococcus,* the aberrant *Nesococcus* and the remarkable *Clavicoccus,* all endemic genera, together with some of the unique *Pseudococcus,* are examples of this endemic development. Surely, a large number of new species and probably some new genera await the careful collector in our mountains. The study of the native mealybugs has only begun. It is unfortunate, however, that most of our native species are now uncommon or rare. It is probable that many species, and

perhaps some endemic genera, are now extinct. There are a number of hymenopterous parasites of the native species, but they are poorly known. It is possible that attack by some of the many imported parasites and predators is a contributing factor to the rarity of at least some, if not most of the native mealybugs. In order better to exemplify this native group, there are included here the descriptions of a number of new forms which I have uncovered during the preparation of this text. These descriptions have been prepared by Professor Ferris, and the new genus and new species are to be credited to him.

Key to the Genera of Pseudococcidae Found in Hawaii

(Based upon slide-mounted adult females.)

1. Abdomen terminating in a heavily sclerotized, solidly fused structure 2
   Apex of abdomen not so formed, although limited sclerotic areas may be present............................. 3

2(1). Antennae normal, not geniculate, seven-segmented; body strongly and peculiarly constricted behind hind legs (as illustrated), anal segment deeply emarginate to inset anal ring, caudal lobes strongly developed, heavily sclerotized and each with a pair of protruding cerarian spines; a peculiar mountain form making erect galls on *Urera* leaves.....................**Phyllococcus** Ehrhorn.
   Antennae geniculate, six-segmented; caudal lobes strongly developed and each bearing a long, heavy, arcuate, somewhat blade-like spine; root-inhabiting forms.... ....**Geococcus** Green.

3(1). Caudal end of abdomen deeply invaginated, the anal ring at the cephalic end of the invaginated cylinder; antennae reduced to stubs; legs wanting; body usually heavily sclerotized and distorted at maturity............ ....**Antonina** Signoret.
   Without such a combination of characters............... 4

4(3). Tarsal claws each with a small tooth on the inner margins .... **Phenacoccus** Cockerell.
   Tarsal claws not dentate.............................. 5

5(4). With at least six pairs of cerarii (including the cephalic pair), and in most species with a full complement of 17 pairs 6
   With none to four pairs of cerarii (never more).......... 8

6(5). With 17 pairs of peculiarly developed cerarii, the cerarii either produced into long, sclerotized, spinose processes or produced as sub-hemispherical, sclerotized, spinose processes in known species; dorsum with longitudinal rows of aberrant spinose processes (see figs. 98, 99) ....**Clavicoccus** Ferris.
   Not such species...................................... 7

7(6). Each of the 13 to 16 cerarii composed of two very stout, conical setae set close together and surrounded by a sclerotized area as in figure 97............**Pedronia** Green.
   Not such forms...............**Pseudococcus** (Westwood).

8(5). Peculiar species living on *Pipturus* in the mountains; dorsum with fine, glassy "hair"; derm of dorsum crowded with numerous, conspicuous, large, short-tubed ducts arranged in transverse bands and clusters; no multilocular pores (see fig. 145)............ ....**Nesococcus** Ehrhorn.

Not such species; dorsum without such large, conspicuous, short-tubed ducts (but at least one species with numbers of long-tubed ducts)...................... 9

9(8). Cerarii absent......................**Radicoccus** Hambleton.

Cerarii present.....................................10

10(9). Antennae five- or six-segmented, set very close together at front of head (Although no species of *Ripersiella* have been reported from Hawaii, I have placed the genus in the key for comparative purposes. This genus may yet become established here.)................. ....**Ripersiella** Tinsley.

Antennae seven- or eight-segmented, normal.............11

11(10). Dorsum with unusually large tubular ducts, each with orifice surrounded by a sclerotized area which usually bears one or more small setae; circulus large and crossing intersegmental line............**Ferrisiana** Takahashi.

Dorsum without such large tubular ducts (if ducts are present, they are small and inconspicuous); circulus present or absent, but if present, normally comparatively small and usually confined to fourth abdominal segment and not crossing intersegmental line (present on only one of the species now listed from Hawaii) ....**Trionymus** Berg.

Genus ANTONINA Signoret, 1875

Chaetococcus Maskell, 1898.

This is a conspicuously distinct genus in our fauna and one that fortunately is of no great economic importance. The following diagnosis is by Ferris:

These are Pseudococcidae in which the anal opening is borne at the inner end of an invagination of the apex of the abdomen. In typical forms, legs lacking in adult female, antennae very short and contain only two or three segments. Spiracular plate usually enlarged and each spiracle accompanied by a cluster of small, multilocular pores. Dorsal ostioles tend to become very small and even disappear in some species, although they may at times merely be obscured by sclerotization of derm, instead of lacking. Genital opening, although retaining same morphological position as in other members of family, much farther forward than usual. There are various alterations in pores and ducts and departures from normal form, which have not yet been investigated adequately. Tubular ducts seem to lack the delicate, filamentous extension which is characteristic of these ducts in other Pseudococcidae and terminate in a slightly dome-shaped extension

of the tube. In addition to usual multilocular disc pores, there are present at times other circular structures—presumably pores—which do not show separate loculi.

The group is undoubtedly one of considerable size, although the number of described species probably does not exceed 25. Included in the genus at the present time are some species which should probably be established in new genera and it is possible that when the group has been adequately studied one of the species here included in *Antonina*—*A. bambusae* (Maskell)—will need to be re-established in the genus *Chaetococcus,* which was once erected for it. All the members of the group, with the exception of one, occur on grasses. The exception is *Sphaerococcus casuarinae* Maskell, which occurs on *Casuarina,* and in which the legs remain at maturity.

Key to the Species of Antonina Reported from Hawaii

1. Adult female a large (5 mm. or longer), dark-brown, heavily sclerotized, conspicuously seed-like creature living under bamboo leaf sheaths and surrounded by a white secretion; abdomen at maturity tapering sharply, segment by segment, in a stair-step manner, terminal segment quite narrow..**bambusae** (Maskell).
   Not such insects, smaller, body at most sclerotized only caudad; on bamboo and other grasses; abdomen at maturity with segmentation hardly or not at all indicated at margins... 2
2. Not found on bamboo, usually found on other grasses, especially Bermuda grass; with a small, but quite distinct, invaginated pouch just posterior to each spiracle; multilocular disc pores confined to mid-region of abdominal venter and to groups about each spiracle............**graminis** (Maskell).
   Bamboo-infesting species, living at bases of leaves and enclosed in a felted sac; without such a pouch behind each posterior spiracle; multilocular disc pores present along entire margin of body, both dorsally and ventrally...**crawii** Cockerell.

Antonina bambusae (Maskell).

Sphaerococcus bambusae Maskell, 1892:236, pl. 16, figs. 12–19.

Kermicus bambusae (Maskell) Kirkaldy, 1902:104.

Chaetococcus bambusae (Maskell), Ehrhorn, 1916:236. Morrison, 1922:56, fig. 18.

Antonina bambusae (Maskell) Fullaway, 1923:310.

The giant bamboo scale.

Oahu (type locality: Honolulu).

Immigrant. A widespread species originally described from specimens collected by Koebele at Honolulu.

Hostplant: bamboo.

The large, hard, adult female is an unusual coccid and is readily recognized. She makes a cottony "bed" of white wax under the leaf sheaths of the host.

Material at hand from "bamboo," Hawaii, collected by Ehrhorn seems to agree with the original description of the species given by Maskell. Unfortunately all the specimens at hand are fully mature and are so heavily sclerotized and pigmented that it is impossible to determine the morphological characteristics of the species. However, it is readily distinguishable from the two other species known in Hawaii by its gross characters. The abdomen tapers rapidly in a stair-step manner, each succeeding segment being narrower than the one before it. (The foregoing paragraph is by Ferris.)

Antonina crawii Cockerell (figs. 89, 90).
Antonina crawii Cockerell, 1900:70.

The cottony bamboo scale.
Oahu.

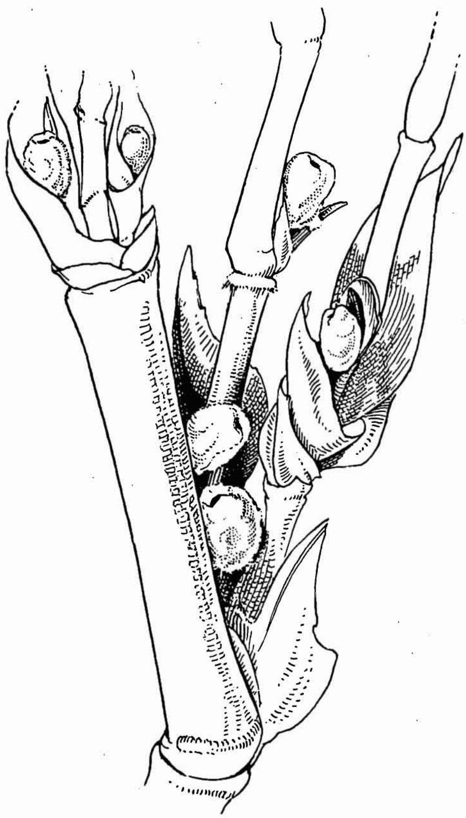


Figure 89—*Antonina crawii* Cockerell, the cottony bamboo scale. (Abernathy drawing.)

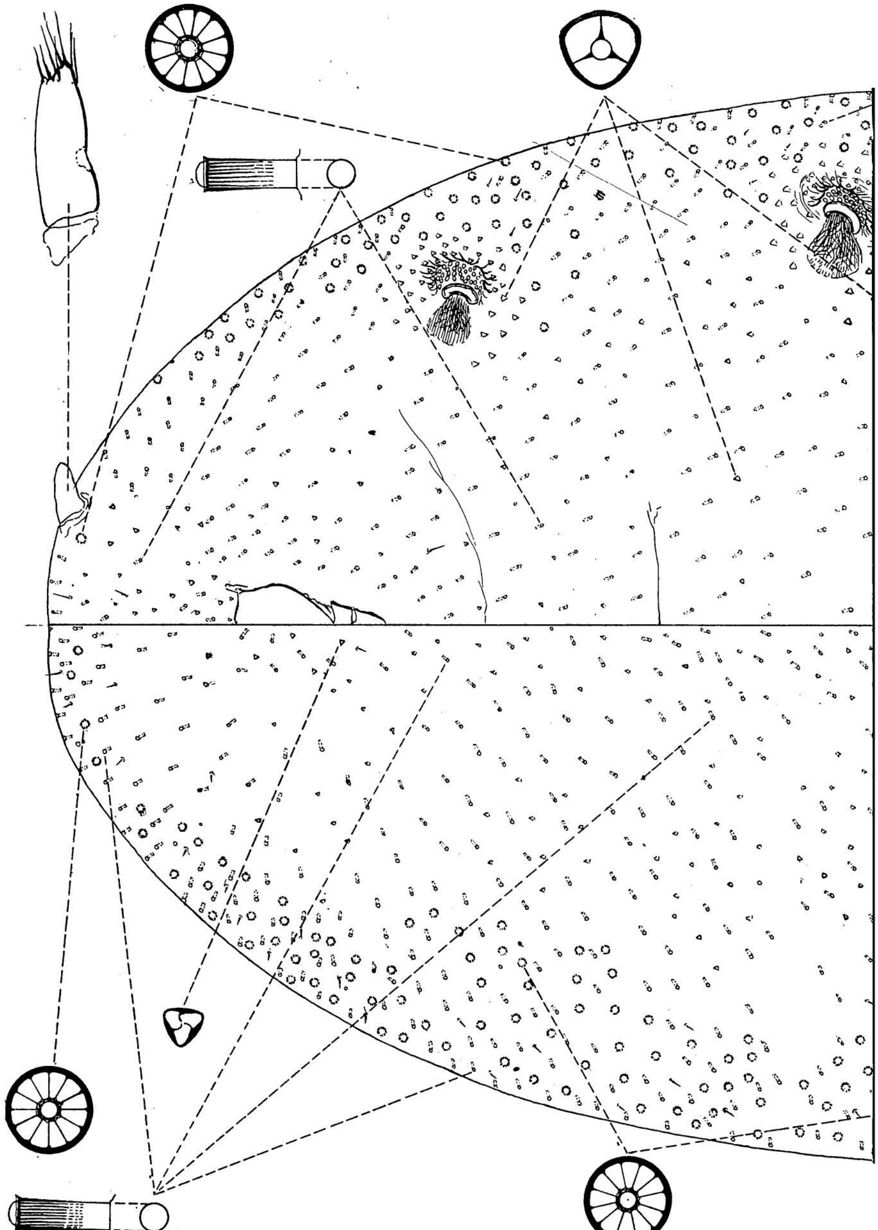
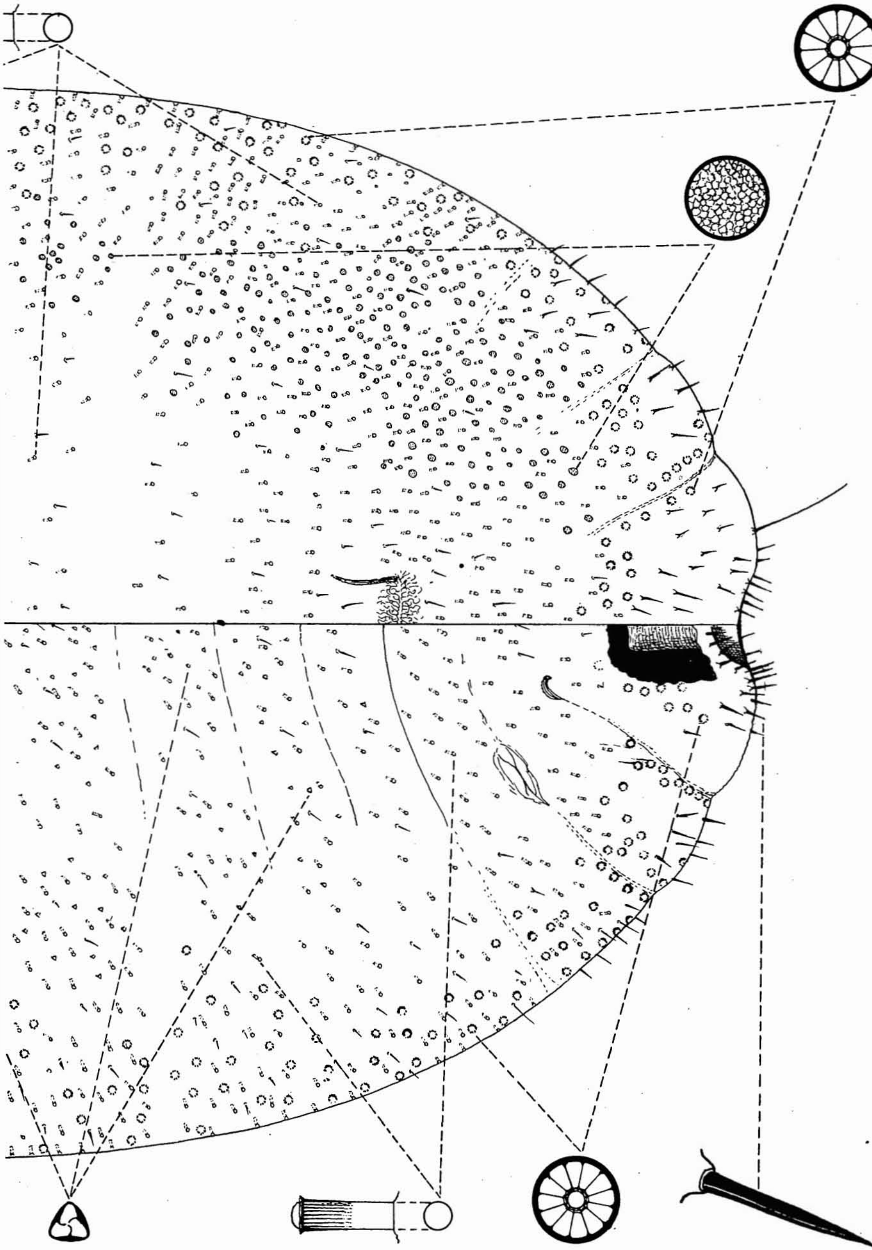


Figure 90—*Antonina crawii* Cockerell, the cottony bamboo scale. (Drawn by Ferri



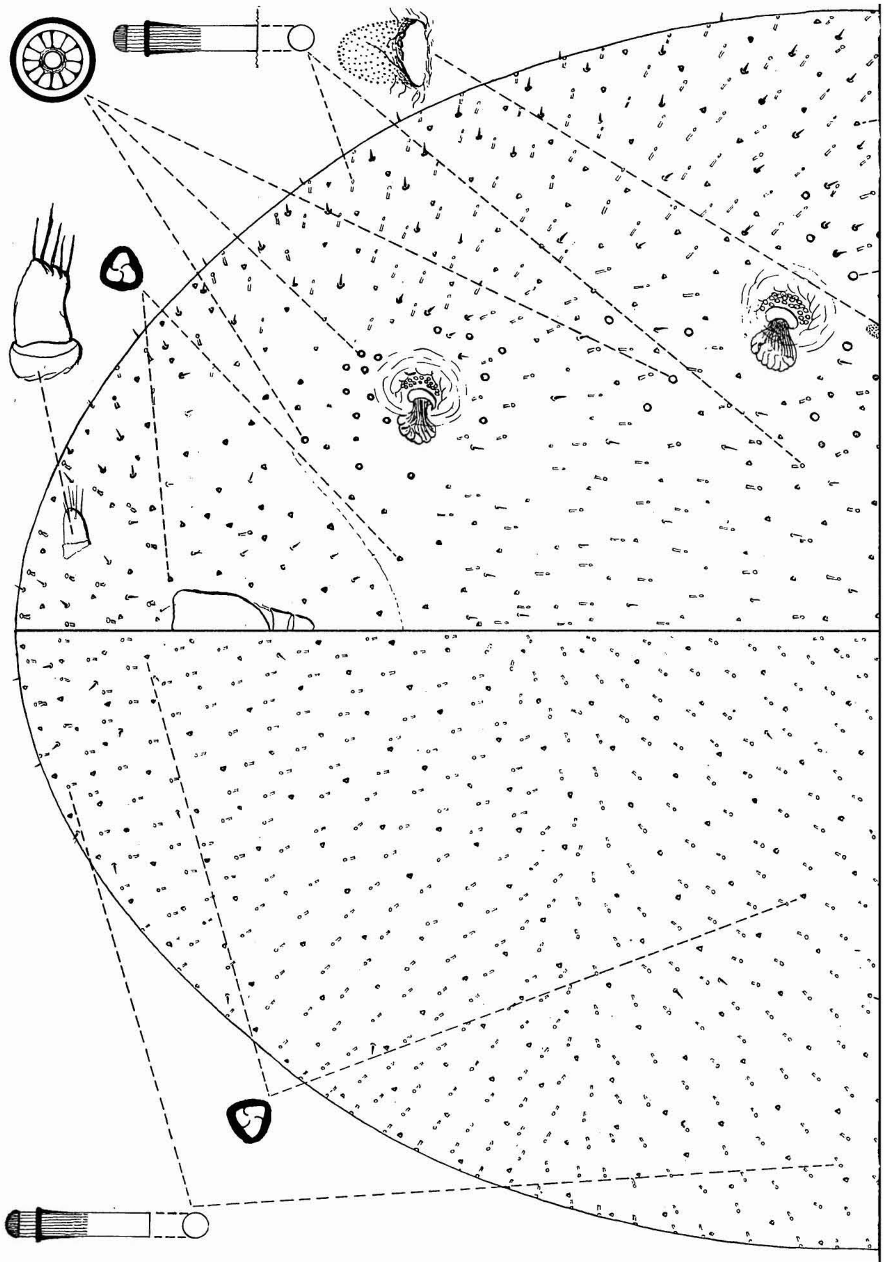
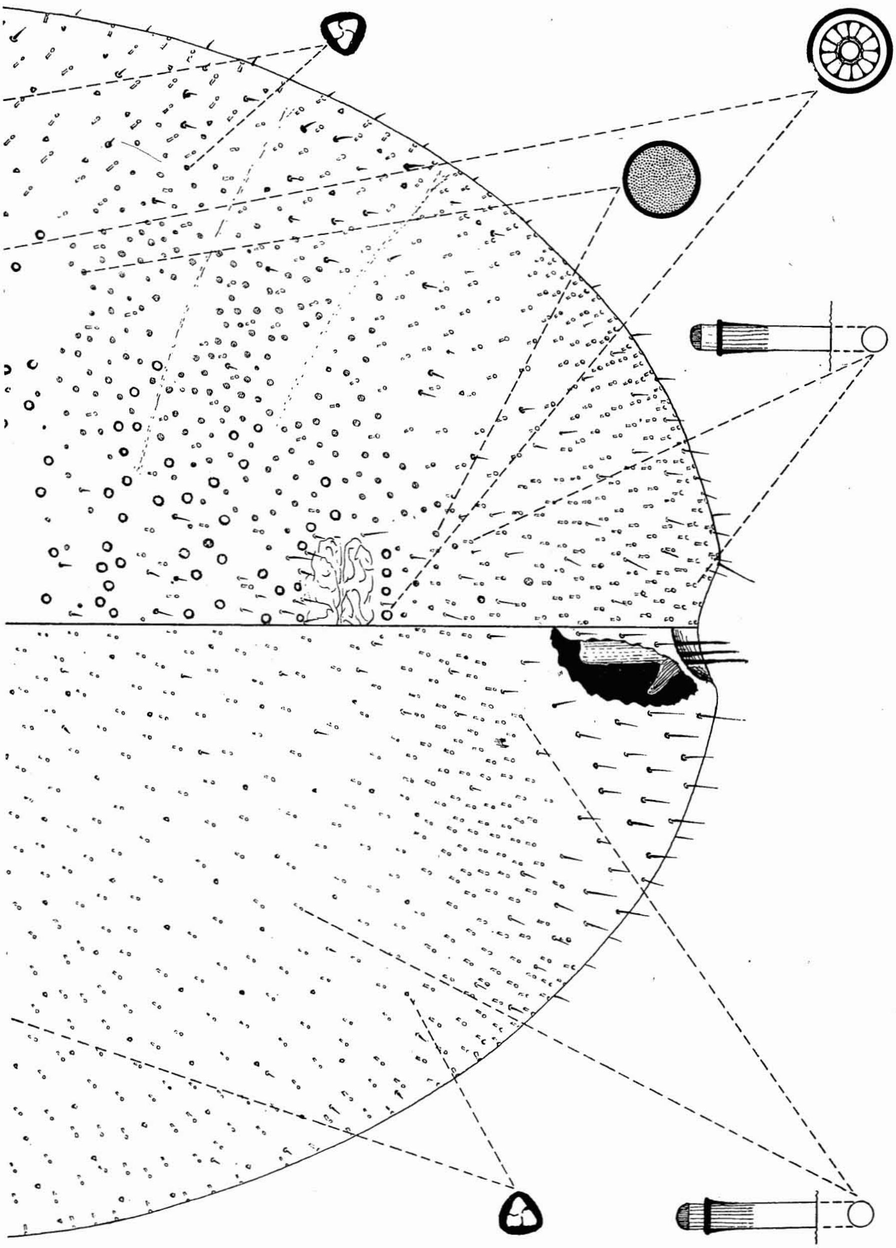


Figure 91—*Antonina graminis* (Maskell), the grass-root *Antonina*. (Drawn by Ferri



Immigrant. Known from Japan and North America. First recorded from the Territory by Ehrhorn in 1916 (p. 236).

Hostplant: bamboo (probably several kinds).

The adult females secrete a felted sac of white wax which encloses them at the bases of the bamboo leaves.

The accompanying illustrations are based upon specimens from "bamboo," at Honolulu, which have been compared with others from bamboo in California and Japan. This species and *Antonina graminis* (Maskell) can readily be distinguished from *A. bambusae* (Maskell) by the form of the body; *bambusae* has the abdomen tapered in a stair-step manner. From *A. graminis, crawii* may be distinguished, in preparations made from specimens in which the body has not yet become strongly sclerotized, by the following characters: Multilocular disc pores numerous along the margin of the body from the last segment to the head and not present on the mid-region of the abdominal venter. Trilocular pores, which are quite small and few on both dorsal and ventral sides, becoming much larger in the area about each spiracle and here passing over by various intermediate forms into multilocular pores. There is definitely no invaginated pit posterior to each posterior spiracle. (The foregoing paragraph is by Ferris.)

Antonina graminis (Maskell) (figs. 91, 92).
Sphaerococcus graminis Maskell, 1897:244.
Antonina indica Green, 1908:27, pl. 3, fig. 11.

The grass-root *Antonina.*

Oahu, Maui.

Immigrant. Originally described from China, but now widespread. First listed from Hawaii by Kotinsky in 1910 (p. 127) from specimens collected earlier at Honolulu by Koebele (called "*Antonina boutelouae* Parr." by Kotinsky).

Hostplants: aerial roots of sugarcane, *Chloris, Cynodon dactylon* (Bermuda or "manienie" grass), *Panicum spectabile, Panicum torridum, Panicum variegatum, Paspalum* sp., pineapple roots.

Parasite: *Anagyrus antoninae* Timberlake (Hymenoptera: Encyrtidae).

This is a common species about the upper roots and lower stems of various grasses, but the records for pineapple and sugarcane are rare. It once became so abundant on Bermuda grass on a local golf course that the golfers were annoyed by the bees attracted to the resulting honeydew.

The following notes are by Ferris:

The accompanying drawings are based upon specimens on "grass," from Punduluoya, Ceylon, and determined as *indica* by Green. Specimens from *Cynodon dactylon* at Makaha, Oahu, Hawaii, Sept. 1917, collected by E. M. Ehrhorn, agree closely with these.

In the form of the body this species resembles *A. crawii,* both of these species being separable from *A. bambusae* (Maskell) by the fact that the abdomen does not taper in a markedly stair-step manner as in *bambusae.*

In preparations made from specimens taken before the derm has become too sclerotized and pigmented, *graminis* may be recognized by the following characters: Just posterior to each posterior spiracle there is a small, but distinct, pit-like invagination. This appears in all the specimens at hand from Hawaii and Ceylon. Multilocular disc pores are confined to the mid-region of the abdominal venter and to the area about each of the spiracles, there being none along the margins of the body or on the dorsal side. The anal tube bears a few tubular ducts but does not have a band of multilocular disc pores. All trilocular pores are thick walled and of about the same size, there being none of the larger size such as are present about the spiracles in *crawii*. There seem to be differences in the form of the tubular ducts and the multilocular disc pores which are difficult to describe but which can be appreciated from the accompanying illustrations.

Figure 92—*Antonina graminis* (Maskell), the grass-root *Antonina*. A colony at the roots and base of *Chloris*.

Genus **RADICOCCUS** Hambleton, 1946:47

These mealybugs are eyeless, hypogaeic forms; the antennae are short, stout, five- or six-segmented; cerarii absent; anal lobes not developed; each caudal area adjacent to anal ring with three slender setae; body subcircular in outline in slide mounts, sparsely setose.

We know little about this newly described genus, and I have not seen specimens of the Hawaiian species.

Radicoccus hawaiiensis Hambleton.
Radicoccus hawaiiensis Hambleton, 1946:48.

Oahu (type locality: Manoa Valley, Honolulu).

Immigrant. Although it is not yet known whence it came, it is most closely allied to a species found in Europe.

Hostplant: *Coleus* (found by Ehrhorn at the roots of the plant in 1918).

Genus **GEOCOCCUS** Green, 1902

Antennae six-segmented, placed close together, with a pair of heavily sclerotized hooks near them; legs well developed; anal ring setigerous, caudal lobes strongly developed and each bearing an arcuate, heavy, spine-like terminal process; cerarii not evident; trilocular pores present.

Geococcus radicum Green.
Geococcus radicum Green, 1902:262, fig. 3; 1922:361, redescription, pls. 142, 142a. Genotype. Fullaway, 1910:108–109, pl. 4; redescription.

Oahu.

Immigrant. Originally described from Ceylon, but now known to be rather widespread. First discovered in Hawaii prior to 1908 by Kotinsky on Mount Tantalus, Honolulu (Fullaway, 1910:108).

Hostplants: *Acacia koa, Caladium,* croton, *Cyperus rotundus* (nutgrass), ferns, *Gerbera,* mango, palms (especially potted ones), pineapple.

The adult females are enclosed or nearly enclosed in a white sac of brittle, powdery wax and they attack the subterranean parts of the plants. The characteristic shape of the caudal lobes and their appendages, together with the pair of dorsal accessory hooks on the head and the other pair in front of the anal ring, and its habit will serve to distinguish this unusual coccid.

Genus **PHYLLOCOCCUS** Ehrhorn, 1916:234

Pseudococcidae of which the only known species is a gall-maker, forming deep, pit galls on the leaves of the host. Body markedly pyriform, composed mostly of swollen head and thorax, the small abdomen narrow and forming scarcely more than a third of total length. Four terminal segments of abdomen expanded laterally and strongly sclerotized dorsally, this sclerotized area forming a shield which closes orifice of gall. Terminal part of shield formed by the flattened, leaf-like and mesally approximate anal lobes, which are separated by a membranous fold from plate formed by three preceding segments. The cellular anal ring with its six quite long and stout setae concealed beneath bases of lobes. Antennae seven-segmented. Legs remaining at maturity, but short and stout. Dorsal ostioles lacking. Cerarii lacking, except as represented by a pair of short, conical setae at apex of each anal lobe. Tubular ducts lacking. Pores represented only by trilocular type.

The type of this genus is an extraordinary form which is known only from the Hawaiian Islands, where it is associated with *Urera*. The association between gall-making forms and their host is usually so specific that both must be considered together in determining endemicity. [The three *Urera* species in Hawaii are endemic members of a pan-tropic genus. I consider *Phyllococcus* endemic. E.C.Z.]

While the genus lacks the most characteristic features of the Pseudococcidae, namely, dorsal ostioles, definite cerarii, circulus and distinctive tubular ducts, the presence of trilocular pores and the character of the antennae definitely indicate its assignment to this family.

A single male is at hand, but is not in such condition as to permit its illustration. It agrees, however, with what seem to be the general characteristics of the Pseudococcidae. First-stage larvae, contained within the body of a female, likewise agree well enough with this stage in other Pseudococcidae, except for the absence of dorsal ostioles, but like the male, are not in sufficiently good condition to permit illustration. (The foregoing account has been prepared by Ferris.)

Phyllococcus oahuensis (Ehrhorn) (fig. 93).

Cissococcus (?) *oahuensis* Ehrhorn, 1912:149, pl. 5.

Phyllococcus oahuensis (Ehrhorn) Ehrhorn, 1916:236.

Endemic. Oahu (type locality: Mount Tantalus), Lanai.

Hostplants: *Urera glabra, Urera sandwicensis.*

This unusual species forms erect galls on the leaves of the hostplant, and there may be clusters of galls formed on single leaves. It is heavily parasitized by a small chalcid wasp of undetermined identity. The record from Lanai is new. I obtained the material from herbarium specimens collected in 1910. Ferris has verified the identification.

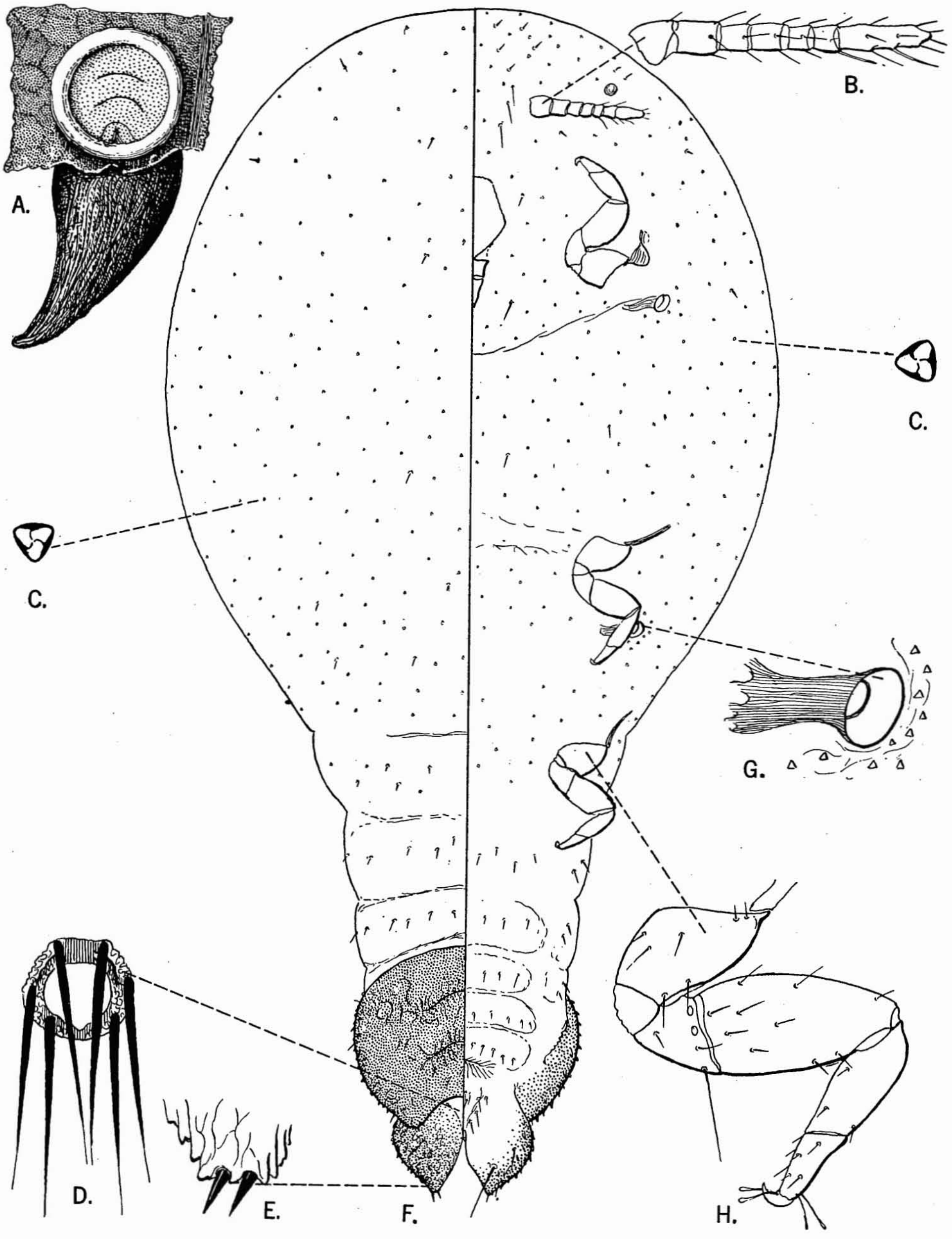


Figure 93—*Phyllococcus oahuensis* (Ehrhorn). **A,** habit; **B,** antenna; **C,** trilocular pore; **D,** anal ring; **E,** anal lobe cerarius; **F,** adult female; **G,** spiracle; **H,** leg. (Drawing by Ferris.)

Genus **PHENACOCCUS** Cockerell, 1893

While normally the antennae in this genus are nine-segmented, one species herein considered has them normally eight-segmented. This species is held in *Phenacoccus,* however, because of its toothed claws, its 18 pairs of cerarii and the somewhat indefinable, but nevertheless significant, character of the dorsal setae of the body which have a form that is generally found in *Phenacoccus.* While the tooth on the claws is small in some species and is an apparently insignificant character, it correlates so nicely with other characters that it offers a good index tab by which the species may be sorted. Occasionally specimens of *Pseudococcus* are found in which there may be some doubt regarding the present or absence of the tooth, but repeated examination of such specimens has shown that if the claw be turned flat on its side, no tooth can definitely be demonstrated to exist, while conversely the claw of a species of *Phenacoccus* in the same position will definitely show the tooth. Actually, there exists a series of genera in which this tooth is present: (Ferris.)

This is the only genus of the family now known to occur in Hawaii that has toothed tarsal claws, but the denticle is small, obscure and might be overlooked easily in our species.

Key to the Phenacoccus Reported from Hawaii

1. Antennae normally nine-segmented; dorsal body setae long and conspicuous, tapering from base, not at all lanceolate; circulus very large, extended on each side into a narrow, lateral arm; multilocular disc pores abundant on dorsum and along posterior margin of four or five segments as well as being present on venter of abdomen.. **gossypii** Townsend and Cockerell.
2. Antennae normally eight-segmented, but at times nine-segmented; dorsal body setae small, characteristically lanceolate; circulus quite small and usually oval, sometimes circular; multilocular disc pores confined to venter of abdomen.................................... **solani** Ferris.

Phenacoccus gossypii Townsend and Cockerell (figs. 94, 95).
Phenacoccus gossypii Townsend and Cockerell, 1898:170.

The Mexican mealybug.

Oahu, Molokai, Maui.

Immigrant. Known from Mexico and widely distributed throughout the United States on many hosts. First recorded from Hawaii by Fullaway in 1937 from specimens taken at Honolulu.

Hostplants: *Capsicum frutescens longum* (cayenne pepper), *Crotalaria, Chrysanthemum, Dombeya,* eggplant, *Erigeron, Erythrina, Erythrina caffra,* garden bean (a minor pest), *Heliconia,* lima bean, tomato.

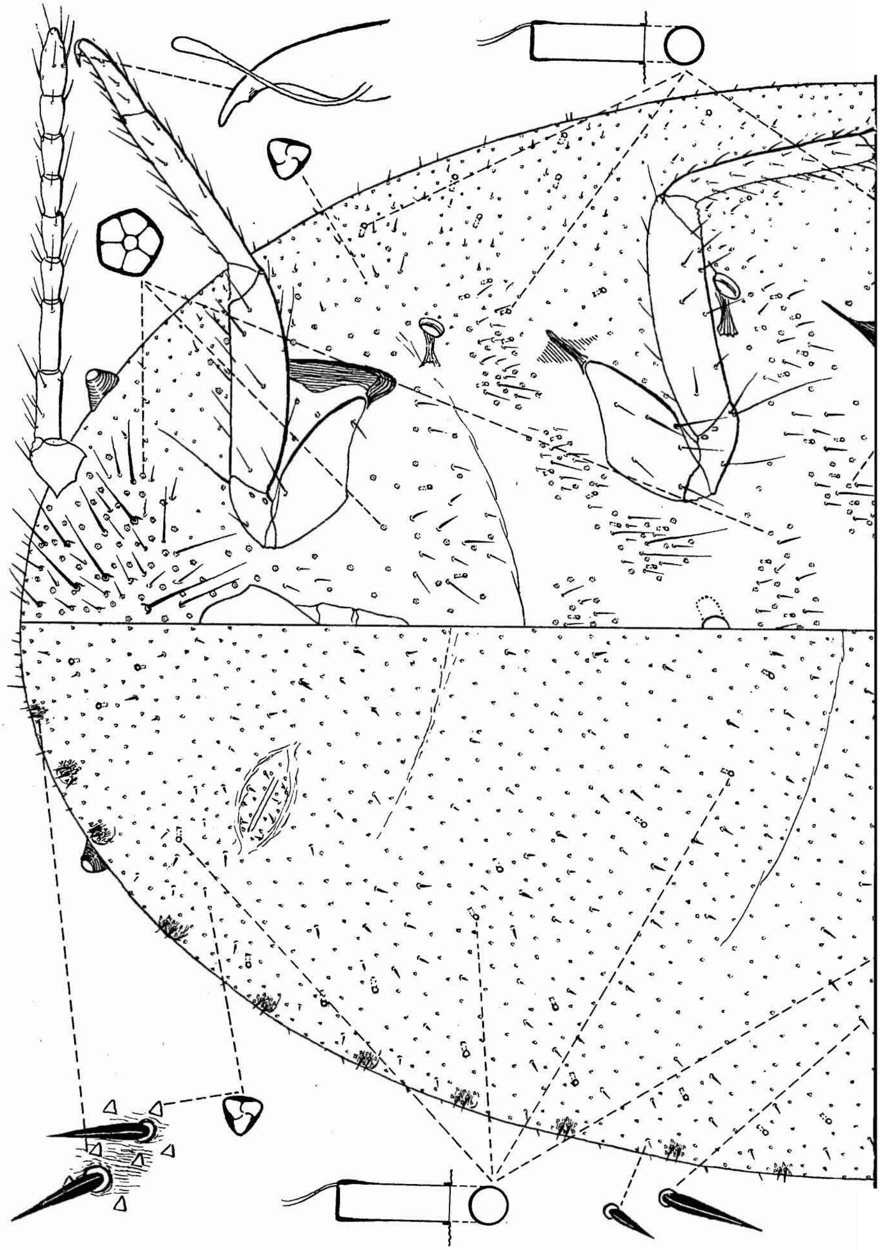
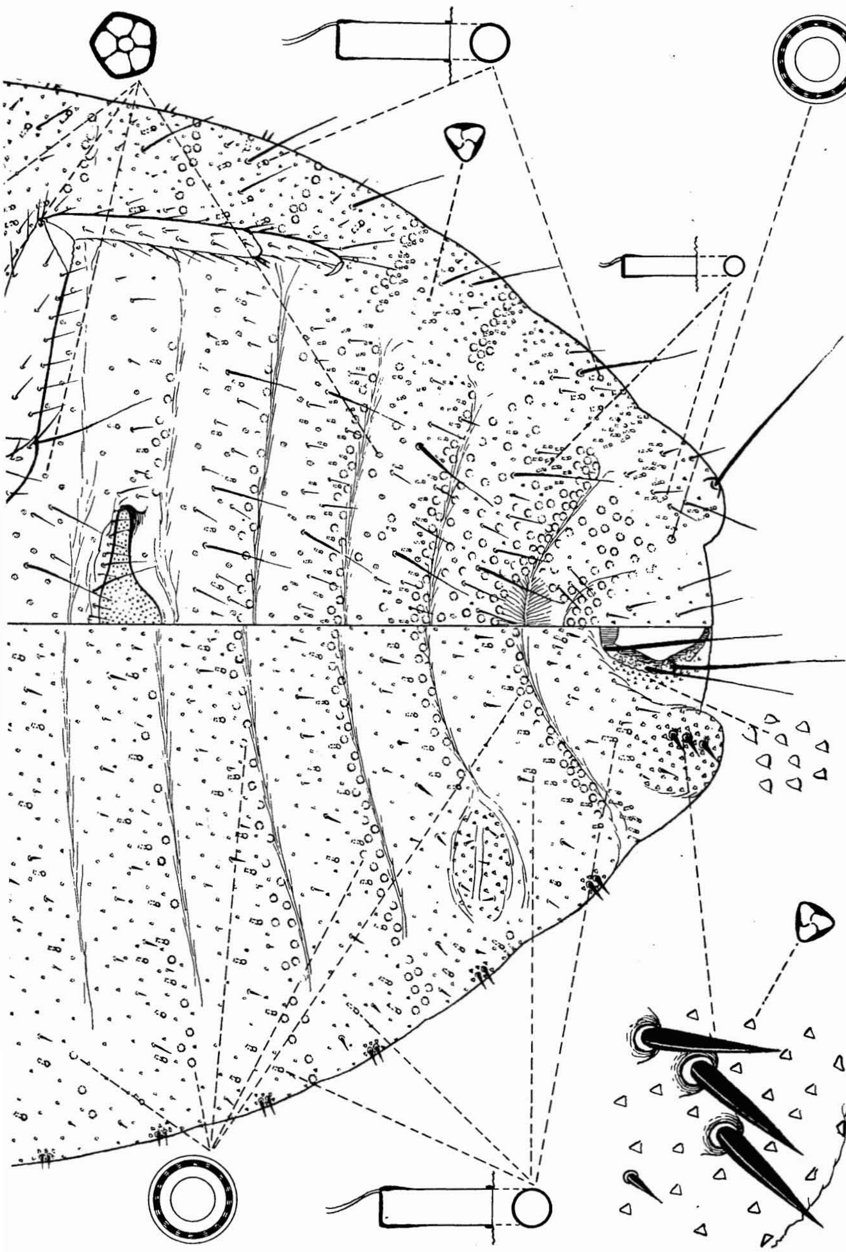


Figure 94—*Phenacoccus gossypii* Townsend and Cockerell, the Mexican mealybug. (Draw
by Ferris.)



This is most distinctive and easily recognizable, its particular combination of characters not being known at present in any other species. The most immediately noteworthy character is the form of the circulus, this being relatively very large and produced into a narrow lateral arm on each side. In unmounted specimens the circulus can be seen to be elevated from the body wall, especially at the extremities, these extremities at times appearing almost as little horns. So strongly is this character developed that it can be recognized in fresh material even under a low magnification. The second distinctive character is the presence of numerous multilocular disc pores on the dorsum of the abdomen along the posterior margins of most of the segments. A third character, which can be clearly seen only in well-stained material, is the presence of numerous quinquelocular (pentagonal) pores on the venter, especially in the thoracic and head region, these pores in some specimens almost replacing the usual trilocular pores in these areas. The accompanying illustrations have been made from specimens from cultivated bean from Palo Alto,

Figure 95—*Phenacoccus gossypii* Townsend and Cockerell, the Mexican mealybug, on a leaf of *Erythrina caffra.*

California. These specimens have been compared with specimens from the type material which have been made available by Dr. Harold Morrison. (This paragraph is by Ferris.)

The long eggsacs are characteristic, and they may be sinuous and twice as long as the adult females.

Phenacoccus solani Ferris (fig. 96).
Phenacoccus solani Ferris, 1918:60, pl. 2, fig. 21.

Oahu.

Immigrant. Described from California. First reported from Hawaii by Suehiro in 1936 (1937:430) from specimens collected in Honolulu.

Hostplants: *Portulaca, Sonchus oleraceus* (at the roots).

The following information has been supplied by Ferris:

This is a rather peculiar species, not conforming entirely to the characteristics of the genus *Phenacoccus,* yet seemingly, on the basis of the totality of its characters, referable there. The antennae are normally eight-segmented, but specimens are at hand in which a ninth segment, formed by the division of the eighth, is present. The tooth on the claw is definitely present but is quite small. Eighteen pairs of cerarii are present.

Apart from the eight-segmented antennae, the distinctive features of the species are as follows: Cerarii all normally with but two somewhat lanceolate setae, except for anal lobe pair which may have two or three small setae of same shape in addition to larger pair. Dorsum very sparsely beset with slightly lanceolate setae of various sizes but all quite small. Tubular ducts entirely lacking on dorsum and present in but extremely small numbers on venter, all quite small, with a slight collar or none and without an oral rim. Multilocular disc pores confined to venter of abdomen, very few, occurring on all segments posterior to circulus. Circulus normally quite small, oval, but in some specimens (even in type lot) somewhat larger and circular, but never produced laterally.

The accompanying figures are from the type material, from the composite *Hemizonia rudis,* at Stanford University, California. The species is widely distributed throughout the United States on many hosts and commonly occurs on the crowns or beneath the surface of the soil.

Whether or not this is identical with *Pseudococcus solani* Cockerell cannot be determined as the whereabouts of the types of the latter is not known.

Genus PEDRONIA Green, 1922:364

The text on this genus is by Ferris.

Pseudococcidae in the known species of which there are 13 to 16 definite pairs of cerarii, each of which is composed of two short and very stout, conical setae that are set very close together; such setae may be present in rows, or may be lacking, on the dorsum; antennae six- to seven-segmented; claw without a tooth;

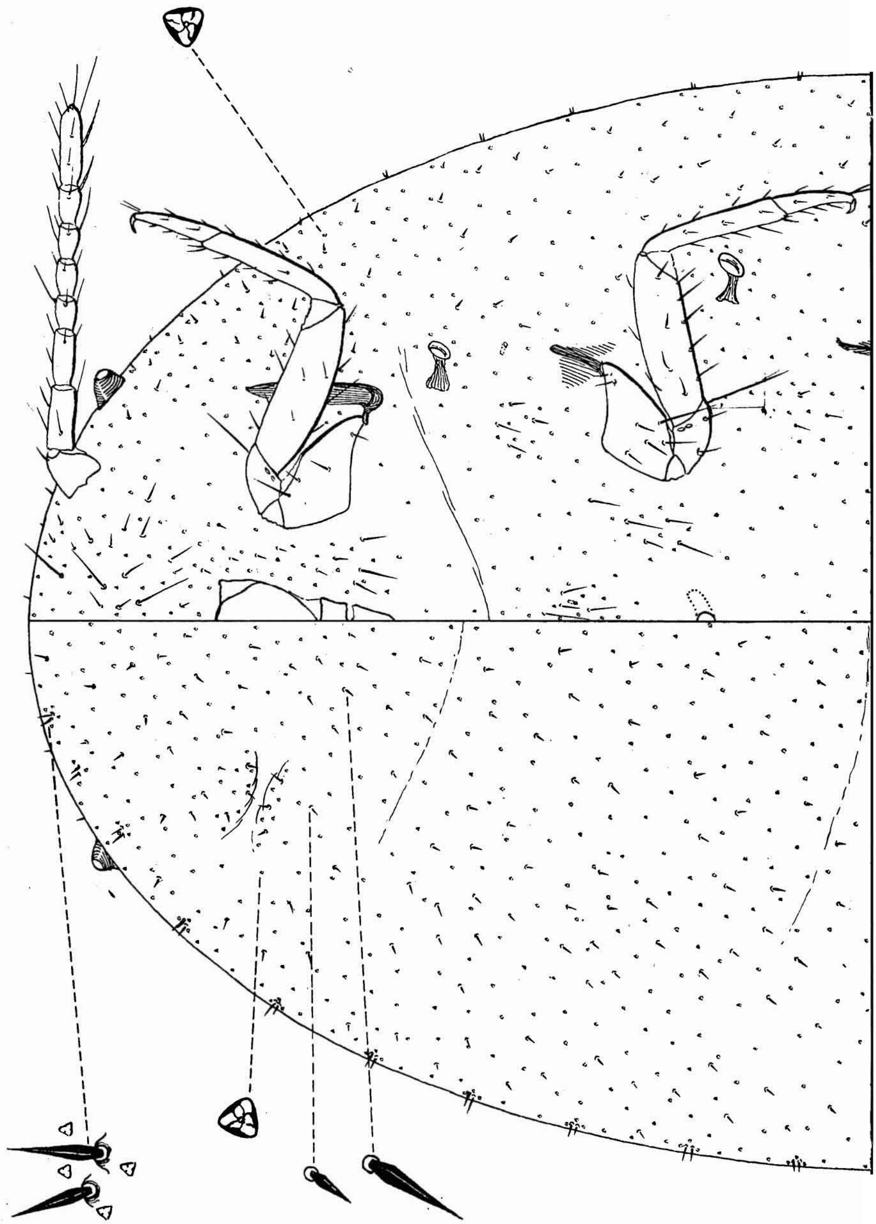
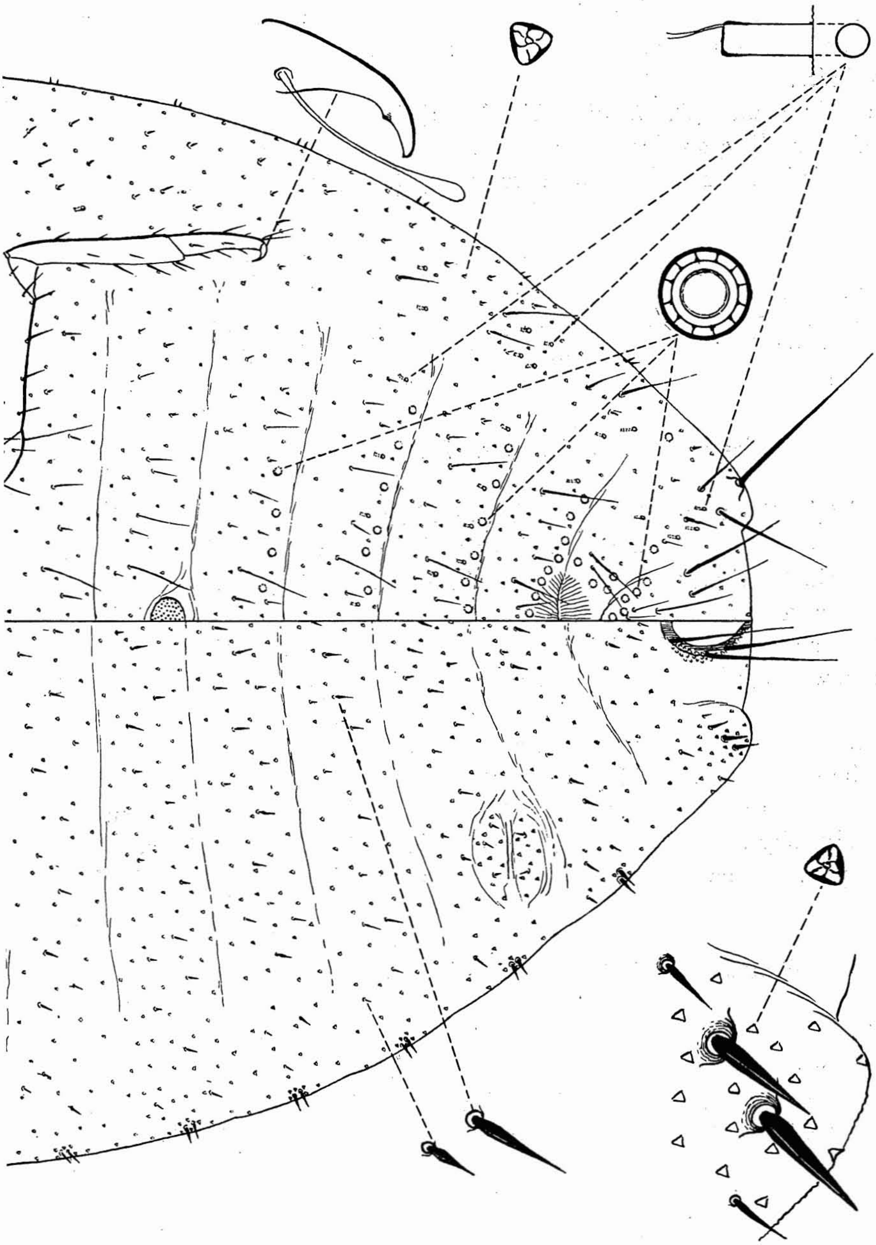


Figure 96—*Phenacoccus solani* Ferris. (Drawn by Ferris.)



circulus lacking in the known species; both pairs of dorsal ostioles present; tubular ducts apparently lacking; multilocular disc pores present or absent, in one known species present in very small numbers only in the region of the vulva; trilocular pores present on both dorsum and venter; anal ring small but well developed, bearing the usual six hairs.

The type of the genus (*P. strobilanthis* Green) is known only from a single record from Ceylon. The species here described seems definitely to be congeneric with it, although it is distinct. The two species may be separated by the following characters:

1. About 13 definite pairs of cerarii present, other marginal setae in head region not being grouped in pairs; conical setae present on dorsum.......................... **strobilanthis** Green.
2. Sixteen definite pairs of cerarii present; dorsum without conical setae............................. **hawaiiensis** Ferris.

Pedronia hawaiiensis Ferris, new species (fig. 97).

Host and distribution: From *Gleichenia linearis,* at about 1,200-foot altitude on the trail to Mount Lanipo, Oahu, T. H., May 24, 1936, Amy Suehiro, collector.

Habit: Found in the tight terminal coils of the fronds of the host.

Recognition characters: Length on the slide about 1 mm. Antennae six-segmented in all the specimens at hand. Sixteen definite pairs of cerarii present, each borne upon a low, slightly sclerotized prominence. Dorsum with very few, extremely small, scattered, slender setae. Multilocular disc pores lacking, the dorsum and venter bearing merely scattered and very small trilocular pores.

Notes: In the opinion here held this species is definitely referable to *Pedronia.*

Described from eight mounted specimens. The type is deposited in the collections of Stanford University and paratypes in the collections of the Bishop Museum.

[In the absence of further information, this species is considered endemic. E.C.Z.]

Genus **CLAVICOCCUS** Ferris, new genus

Pseudococcidae with 17 pairs of cerarii, which in the type are represented by long, sclerotized processes that are beset with stout, conical setae and in the other included species by more or less hemispherical, sclerotized prominences which likewise are beset with such setae; dorsum with rows of clavate or hemispherical processes beset with conical setae; antennae seven-segmented; claw without a tooth; circulus apparently lacking; at least posterior pair of ostioles present; multilocular disc pores lacking; tubular ducts, if present at all, very few and small; trilocular pores present; anal ring of normal form and with six setae.

Several species which bear spinose processes somewhat similar to those present in this genus have been described from various parts of the world, but all of these species have a tooth on the claw, a character which is quite distinctive of the

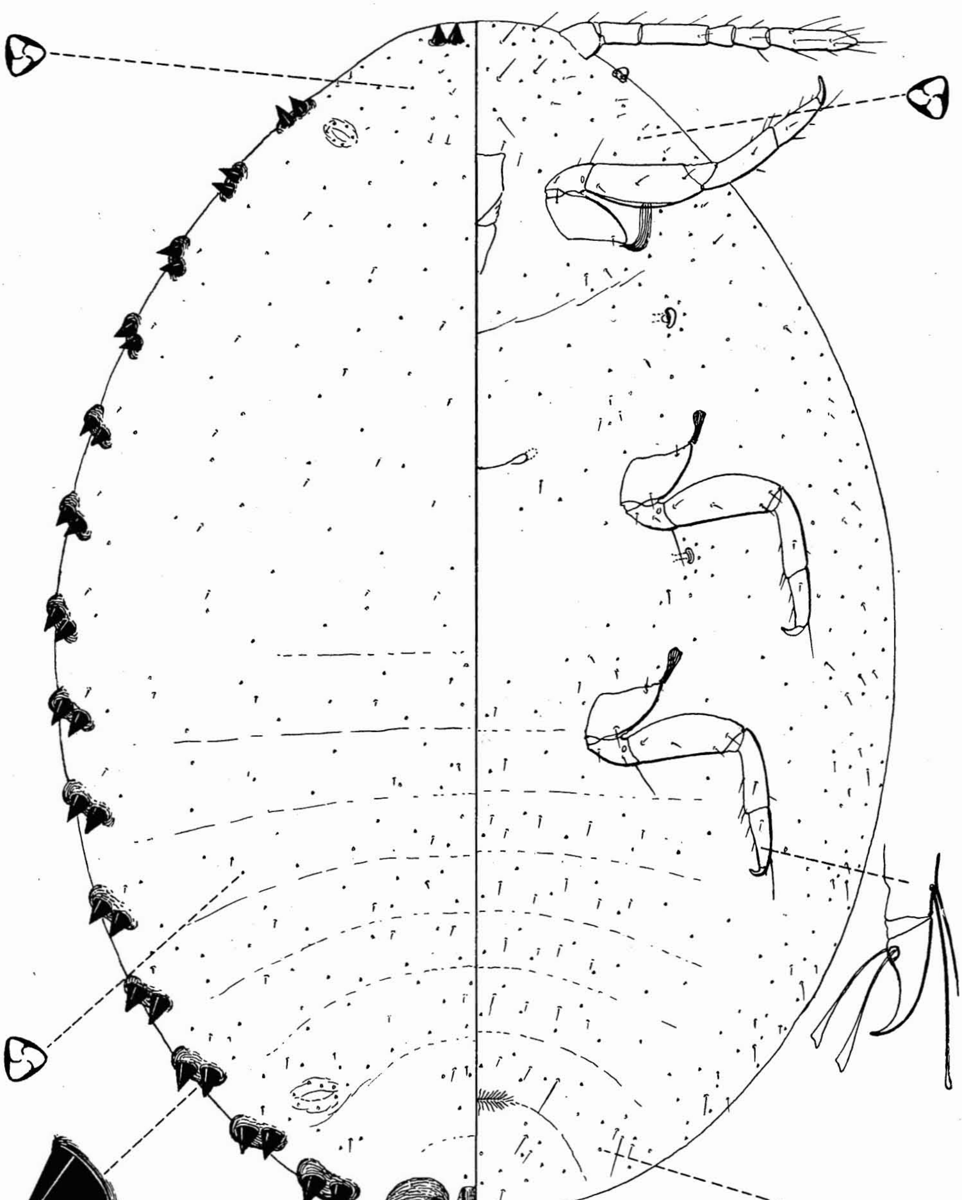


Figure 97—*Pedronia hawaiiensis* Ferris, new species. (Drawn from the types by Ferris.)

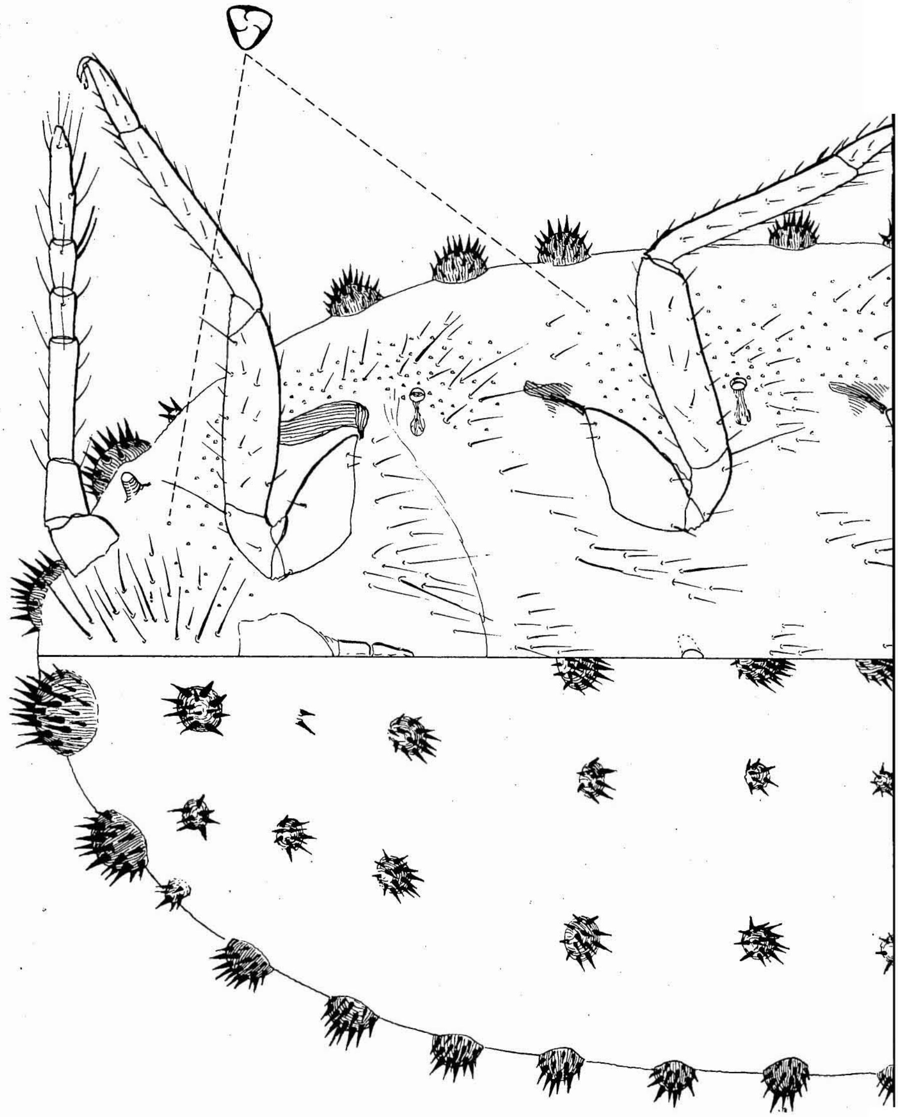
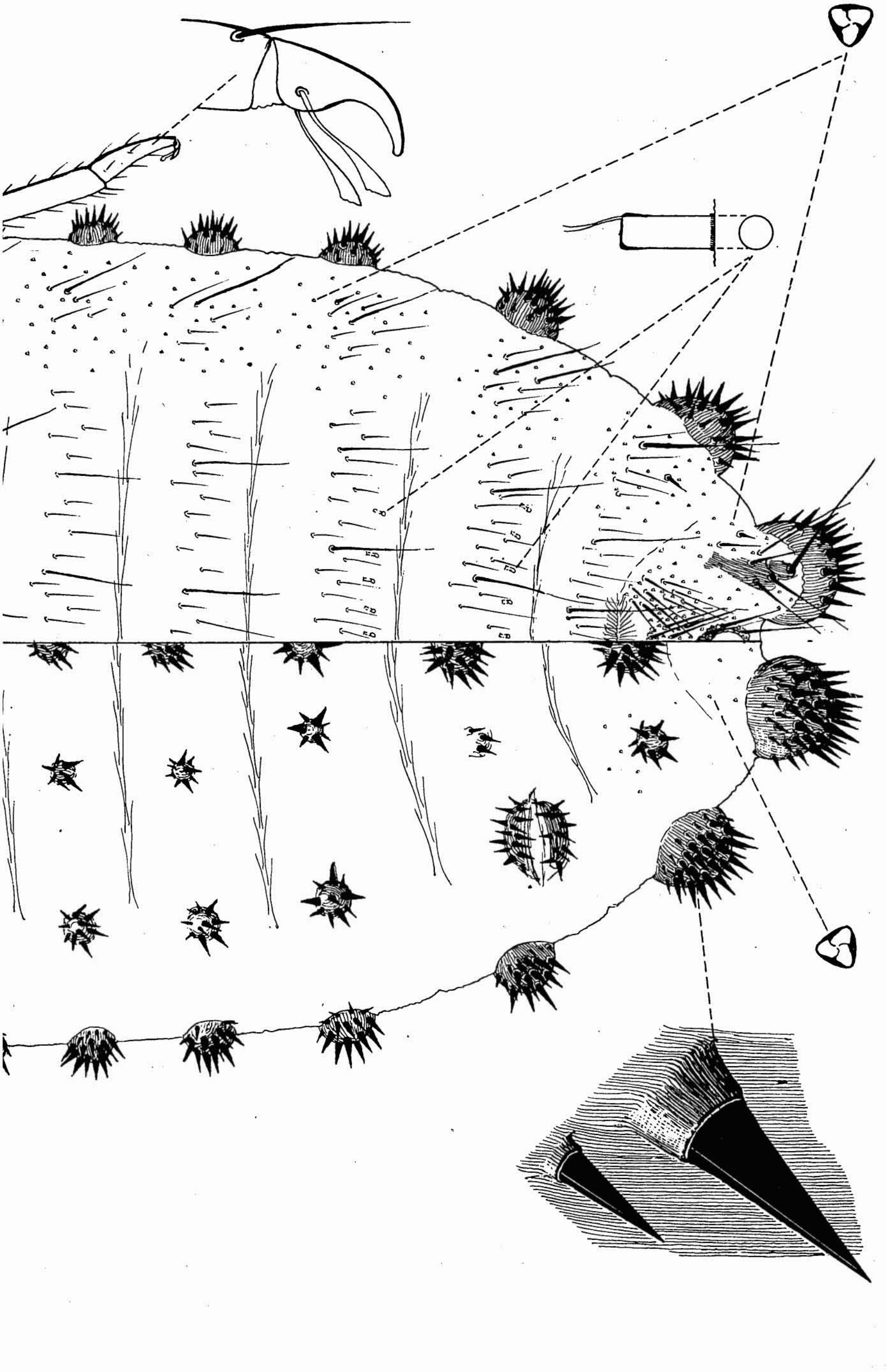


Figure 98—*Clavicoccus erinaceus* Ferris, new species. (Drawn from the types by Fe



Phenacoccus series. It would seem that the tendency to produce such processes has developed more than once. It is carried to its extreme degree in *Clavicoccus tribulus*. In spite of the marked difference in the development of these processes in the two species herein described, they seem rather definitely to belong to a common stock.

The genus and its included species are considered endemic.

Genotype: *Clavicoccus tribulus* Ferris.

Key to the Species of Clavicoccus

1. Cerarii produced as greatly elongated, sclerotized, spinose processes.......................................**tribulus** Ferris.
2. Cerarii in the form of subhemispherical, sclerotized, spinose processes...................................**erinaceus** Ferris.

Clavicoccus erinaceus Ferris, new species (fig. 98).

Hosts and distribution: Known from a single collection from *Abortopetalum sandwicense,* at Kaumokuiki Gulch, Oahu, April 13, 1933, F. X. Williams, collector.

Habit: No information available.

Recognition characters: Length of largest specimen on slide about 3 mm. Body form somewhat elongate and slender. Lateral margins of body with 17 pairs of more or less hemispherical, sclerotized prominences, each of which is beset with numerous conical setae that are for most part borne each on a slight pedicel. These setae vary somewhat in size, those about base of each prominence being smaller than those at apex. Dorsum with five rows of smaller prominences, these smaller than those of abdomen but beset with similar setae. Dorsum entirely destitute of pores or ducts except for a very few extremely small trilocular pores on last two or three segments. Venter with a submarginal zone of such trilocular pores extending almost entirely around body and with very few small, tubular ducts in midregion of two or three abdominal segments anterior to vulva; otherwise without pores or ducts. Anal opening appearing on ventral side of body in all available specimens. Antennae six-segmented, third segment much the longest. Tarsal claw with two flattened digitules and apex of tarsus outwardly with merely a moderately long, apically pointed seta. It is not possible to be certain on the basis of the available specimens, but the circulus seems definitely to be lacking. Anterior ostioles apparently lacking, but perhaps merely obscured.

Notes: There are available only five specimens of this strange species. These had been sent to Washington by their discoverer and were made available for this work through the kindness of Dr. Harold Morrison. They are deposited in the National Museum at Washington, D. C. The short, more or less hemispherical marginal and dorsal processes will distinguish this species immediately from the type of the genus.

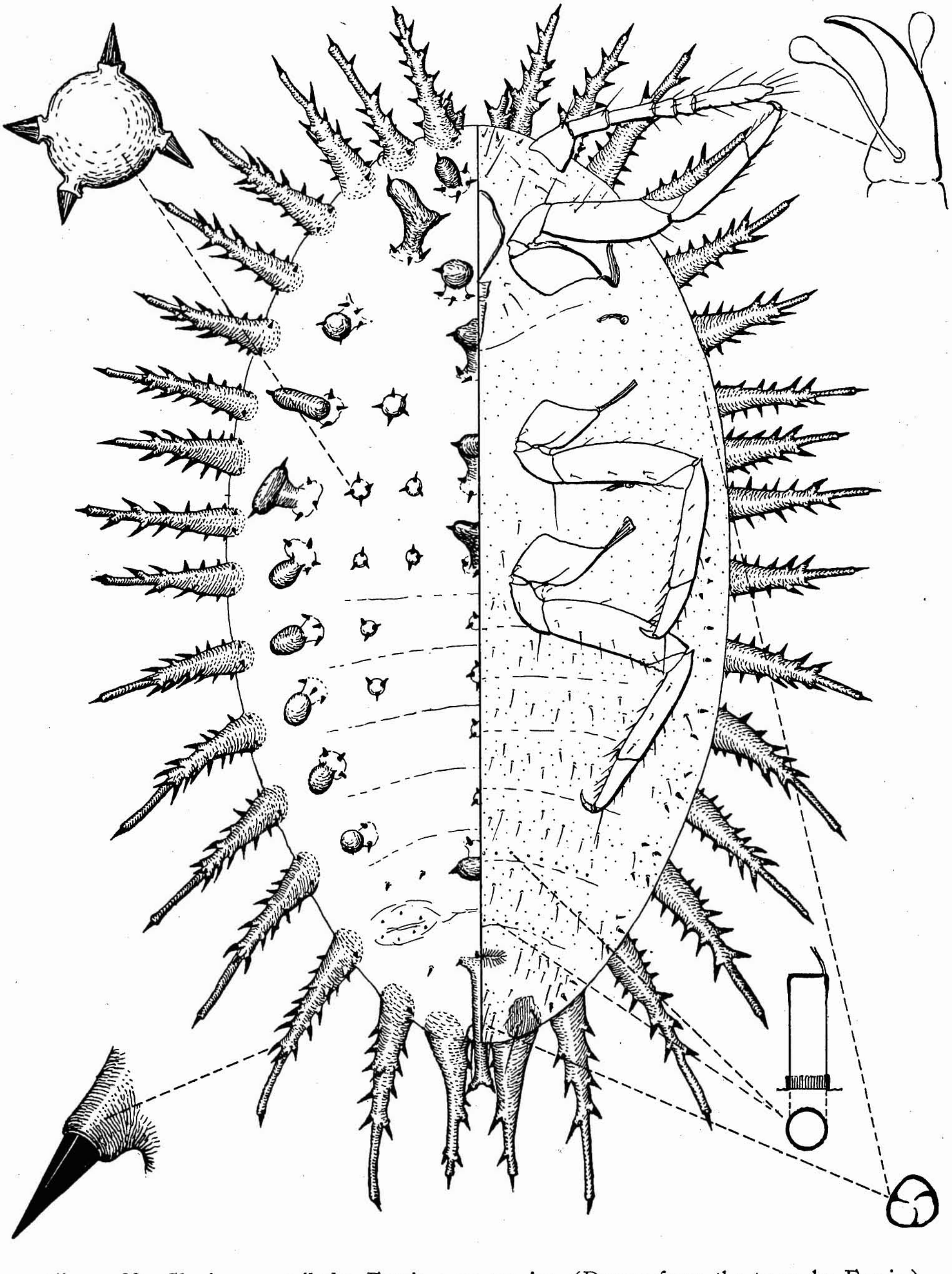


Figure 99—*Clavicoccus tribulus* Ferris, new species. (Drawn from the types by Ferris.)

Clavicoccus tribulus Ferris, new species (fig. 99).

Host and distribution: Known from a single small collection, from "native *Hibiscus,*" Kaluanui Stream, Oahu, Hawaii, May 14, 1946, F. A. Bianchi, collector. Type in the Bishop Museum at Honolulu. Paratypes deposited in the Stanford University Collection.

Habit: Original lot found abundant on leaves of host.

Recognition characters: Length of largest specimen on slide, 2 mm. The extraordinary fringe of marginal processes is immediately distinctive of the species. Of these processes, the anterior-most pair is quite small and inconspicuous, being more or less concealed by a larger neighbor. The 17 long pairs increase somewhat in length posteriorly. In all of these the basal two-thirds is quite stout and is beset with a variable number of short, stout, conical setae along lateral margins, while apical third is slender and bears a single stout seta at apex. Dorsal processes arranged in seven rows, or partial rows. Of these, the submarginal row extends from head to about sixth abdominal segment and includes ten processes of various shapes and sizes, all, however, consisting of a weakly sclerotized pedicel, which bears three or four conical setae, and a more strongly sclerotized and somewhat clavate terminal portion. Second row from margin extends from head to third or fourth abdominal segment and consists of six or more processes which are for most part somewhat spherical and bear three or four conical setae. Third, or submedian, row present only on thorax and contains two small, spherical processes. Median row extends from head to seventh abdominal segment and contains as many as nine processes of varying sizes and shapes, that of seventh segment being elongate and extending past end of body.

Abdominal dorsal ostioles present. Anterior ostioles probably present, since they occur in penultimate stage, but obscured by dorsal processes.

Antennae small and slender, six-segmented. Legs of normal development, claw definitely without a tooth.

Dorsum of body seemingly without pores or ducts except for a few trilocular pores about posterior ostioles. Ventral side of body rather sparsely beset with small, irregular, trilocular pores and with a row of very small tubular ducts on each of two or three segments anterior to vulva. Multilocular disc pores entirely lacking.

Immature stages: Specimens representing penultimate stage are at hand. In these the lateral processes are relatively shorter and broader than in adult and the dorsal processes are smaller and less sclerotized.

Notes: The extraordinary lateral processes, which distinguish this genus and species, seem to be an extreme development of conditions such as appear in the genera *Echinococcus* Balachowsky and *Seabrina* Neves. However, in both these genera, according to their descriptions, there is a tooth on the claw and in *Echinococcus* the antennae are nine-segmented. The indications are that those genera belong to the *Phenacoccus* series.

Genus PSEUDOCOCCUS (Westwood, 1840)

Pseudoccus Westwood, 1840.

This is the largest genus of coccids in Hawaii. It is also the most confusing one taxonomically and contains the most economically important species. The published work on the Hawaiian forms is inadequate and leaves much to be done. Some of the species have distinctive facies while living, especially in regard to the forms of the wax appendages, but others are not easily identified in the field.

The following notes and key are by Ferris:

Not until the genera of mealybugs have been reviewed for the whole world on the basis of an examination of well-prepared material and with a full understanding of the value of the rather limited number of characters available for generic differentiation will it be possible to define this genus with any definiteness. Such a study will probably reveal a whole series of genera which are now concealed in the jungle that is called *Pseudococcus*.

As understood at present, the genus is held together flimsily by the following set of characters: Never with a tooth on the claw. Antennae commonly eight-segmented but frequently with seven segments or even with six, but never with nine. Normally seventeen pairs of cerarii present, but at times with eighteen and frequently with any number less than seventeen down to only three or four, but usually with at least one pair on the head. The circulus, when present, extends across an intersegmental line and is capable of being folded on this line, but it is frequently lacking.

There are certain nomenclatorial problems in connection with this genus that remain to be worked out, but it may merely be noted that unless some special dispensation is made, the name *Pseudococcus* apparently must disappear and give way to *Trechocorys* Curtis.

It is quite clear that there is a series of endemic species of *Pseudococcus* in Hawaii. These include *gallicola, antricolens, floriger, tympanistus, nudus, mendiculus, swezeyi, straussiae* and, perhaps, *montanus*. In spite of certain individual peculiarities, which reach their extreme development in *tympanistus,* all these species except *straussiae* seem to belong to a closely related stock, so much so—in the light of present information—as to convey the feeling that they may possibly have sprung from a single ancestral species which established itself in the area and flowered in the same manner as have certain other groups.

In the present state of our knowledge it is difficult to indicate what connections these species have with the mealybug fauna of other parts of the world, since probably only a beginning has been made even in naming the species of mealybugs, and a large proportion of those which have been named are unrecognizable from the existing descriptions. However, material—for the most part unindentified—which is at hand from Australia and the southwest Pacific conveys a slight suggestion that the connection of the endemic Hawaiian fauna is in that direction. Several species are at hand which are of the same general type as these Hawaiian species, but none seems to be identical with any of the Hawaiian forms mentioned.

The following key must be regarded as somewhat tentative. Several of the species have been represented only by scanty material and consequently we have no knowledge as to the range of variability they may show as more specimens are studied. An attempt has been made to use characters that can be seen in any reasonably good preparation and that are not affected too much by the nature of the preparation. Were well-prepared and well-stained specimens always available, characters not here mentioned could be employed. The key should be used with constant reference to the illustrations of the species and with due regard to biological factors.

Key to the Species of Pseudococcus Known from Hawaii

1. Anal lobe cerarii with three or more conical setae.......... 2
   Anal lobe cerarii with only two conical setae.............. 3

2(1). With cerarii, at least on abdomen, each surrounded by a distinct, sclerotized area, that of anal lobes large and conspicuous; circulus lacking; usually associated with *Pandanus*........................**giffardi** (Ehrhorn).
   With none of the cerarii surrounded by a sclerotized area; circulus present; usually associated with palms........ ....**palmarum** (Ehrhorn).

3(1). Dorsum beset with at least a few, stout, more or less lanceolate setae, these being especially noticeable along midline of abdomen 4
   Dorsum without such setae; if any lanceolate setae are present they will be very small and slender.............. 5

4(3). Dorsum with small, slender, tubular ducts............ ....**vastator** (Maskell).
   Dorsum entirely without tubular ducts.......**nipae** (Maskell).

5(3). With numerous, short, broad, "drum-like" ducts, the diameter of which is as much as three or four times that of a multilocular disc pore...............**tympanistus** Ferris.
   With only ordinary tubular ducts of various sizes, none being greater in diameter than a multilocular disc pore.... 6

6(5). Ventral side of anal lobes with a distinct, narrow, bar-like sclerotization extending in from the base of anal lobes ....**citri** (Risso).
   Ventral side of anal lobes with or without a sclerotized area, but if such an area is present, it is never in the form of this narrow bar.......................... 7

7(6). Two or more abdominal cerarii anterior to the anal lobes, each with normally three or more conical setae....... ....**brevipes** (Cockerell).
   No abdominal cerarius with more than two conical setae.... 8

8(7). Ventral side of anal lobes with a quite large, distinct, sclerotized area, the mesal border of which is very strongly sclerotized; all, or nearly all, cerarii accompanied dorsally by two or three oral rim ducts, of which one is larger than the others..............**adonidum** (Linnaeus).

Ventral side of anal lobes with or without a sclerotized area, but this, if present, never with such a strongly sclerotized mesal border; oral rim ducts, if present dorsally, not thus arranged near cerarii 9

9(8). Each cerarius with two large, conical setae, which are of nearly the same size in all cerarii and are surrounded, in all cerarii, by a closely set cluster of numerous pores which tend to form a slightly cup-like area .... **straussiae** Ehrhorn.

Not so 10

10(9). With 17 clearly recognizable pairs of cerarii 11

With at least some of the cerarii, especially in the thoracic region, tending to disappear or to be so greatly reduced that they are unrecognizable, there not being more than 13 or 14 pairs recognizable 12

11(10). Anal lobe cerarii surrounded by a crowded cluster of pores but with at most only a slight accompanying sclerotization .... **maritimus** (Ehrhorn).

Anal lobe cerarii surrounded by a quite large and very definite sclerotized area .... **citriculus** Green.

12(10). With a well-developed circulus present 13

Circulus lacking or very small and indistinct (The key is weak at this point because of the lack of adequate material. In the single available specimen of *mendiculus* a very small and weakly defined circulus is present. It is so faint that it would not be recognizable at all in a poorly stained specimen. The examination of further material may show that it is variable or, at times, lacking.) 17

13(12). Entirely without oral rim ducts; as far as known, occurring normally on sugarcane .... **boninsis** (Kuwana).

Oral rim ducts, or at least ducts with slightly elevated orifices, present 14

14(13). With many conspicuous, short, broad ducts over entire dorsum and near cerarii both dorsally and ventrally, these ducts having orifices slightly elevated and showing a slight oral rim .... **montanus** Ehrhorn.

With definite oral rim ducts relatively few, scattered and with not more than one dorsally near any cerarius 15

15(14). Oral rim ducts of abdomen confined normally to dorsal side of body .... **swezeyi** Ehrhorn.

Oral rim ducts of abdomen present on ventral side as well as on dorsum, there being normally a ventral duct associated with most cerarii 16

16(15). Antennae normally seven-segmented; anal lobe cerarii surrounded by a well-defined sclerotized area .... **antricolens** Ferris.

Antennae normally eight-segmented; anal lobe cerarii either without surrounding sclerotization or this diffuse and indefinite .... **gallicola** Ehrhorn

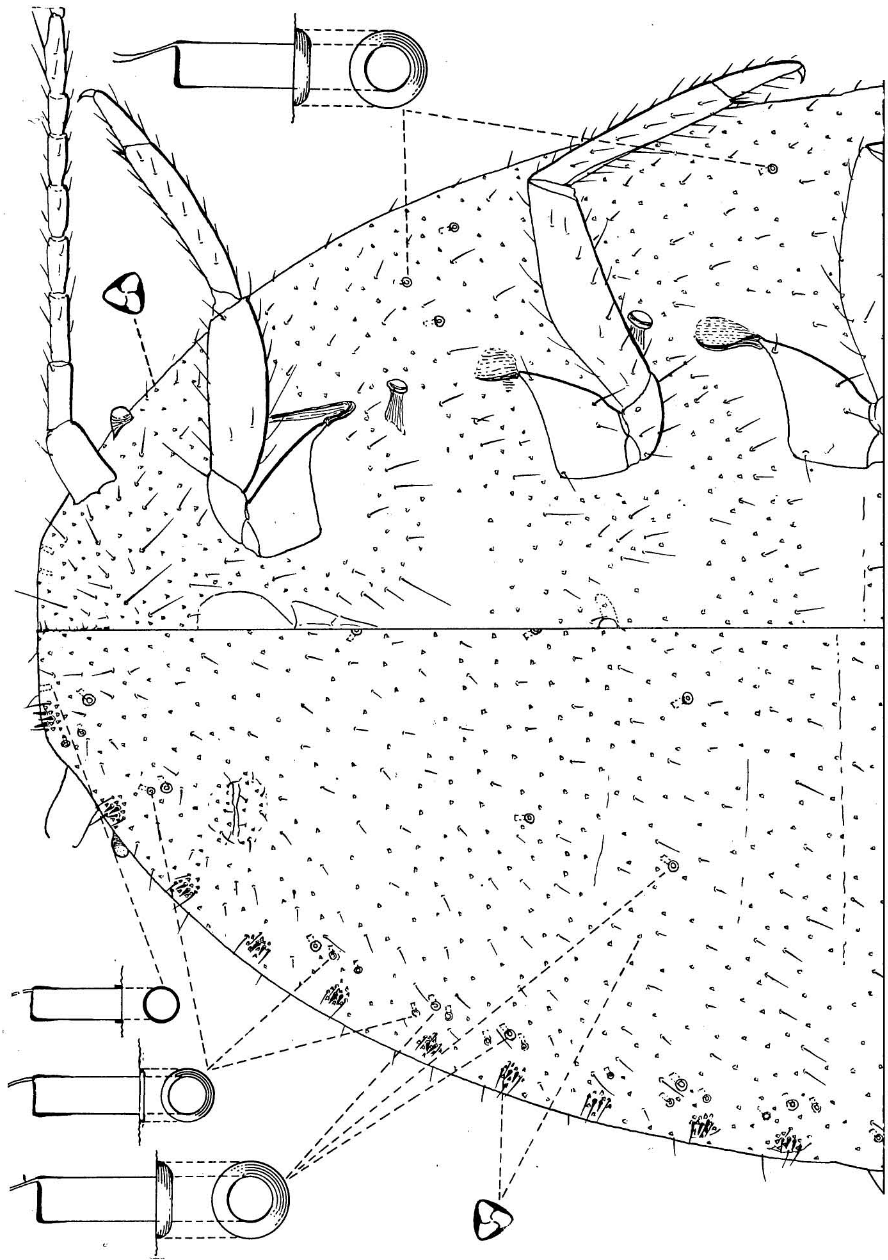
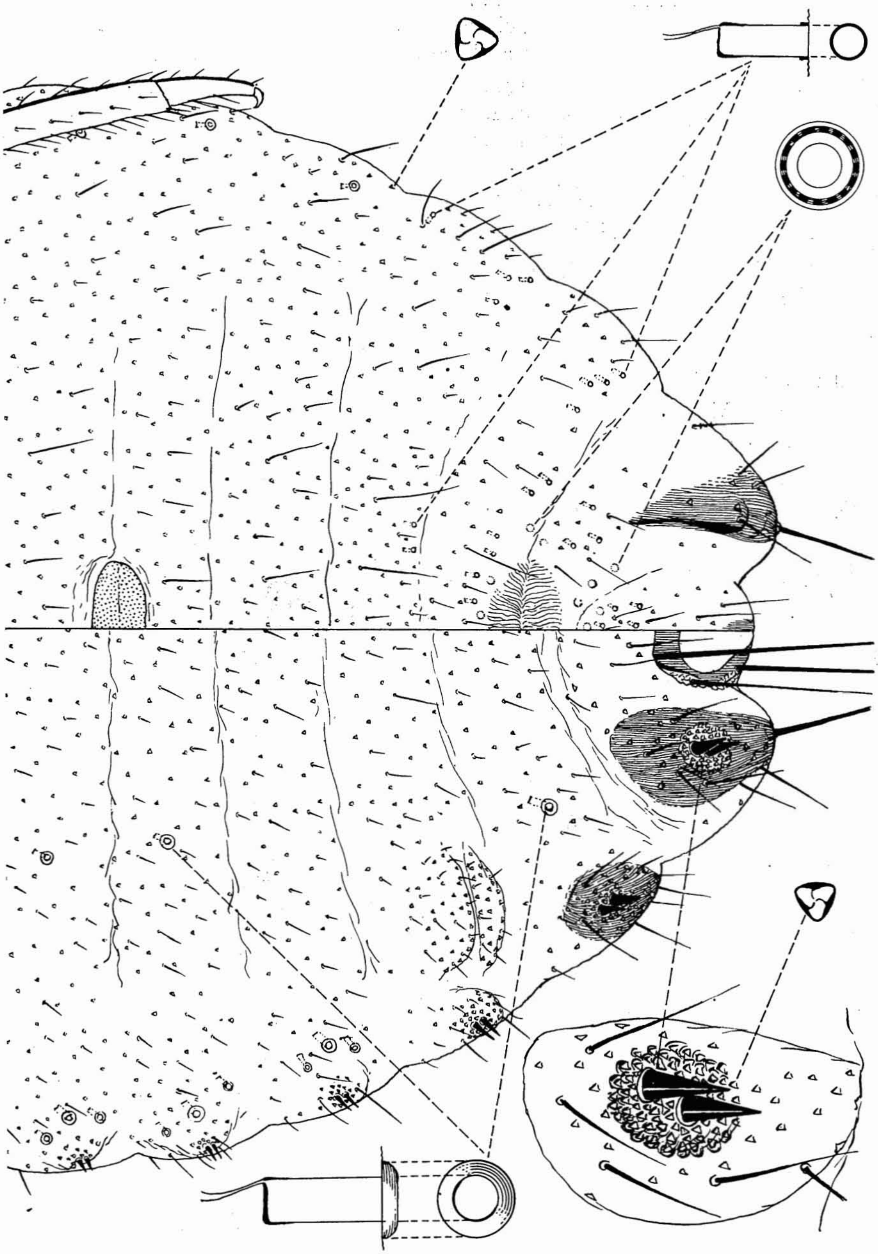


Figure 1[illegible]0—*Pseudococcus adonidum* (Linnaeus), the long-tailed mealybug. (Drawing by



17(12). Marginal areas of body, from head to penultimate abdominal segment, with many short, broad ducts, each with an oral collar . . . . **floriger** Ferris.
Such ducts either entirely lacking in marginal areas or reduced to one or two near each cerarius 18

18(17). Oral rim ducts entirely lacking . . . . **mendiculus** Ferris.
Oral rim ducts present in a dorsal, submarginal series, there being one near each of most cerarii . . . . **nudus** Ferris.

Pseudococcus adonidum (Linnaeus) (figs. 100, 101).

Coccus adonidum Linnaeus, 1758:455.

Pseudococcus longispinus (Targioni-Tozzetti, 1869), of authors.

Trechocorys longispinus, of authors.

Genotype of *Pseudococcus.*

The long-tailed mealybug.

Oahu, Molokai, Lanai, Maui.

Immigrant. A nearly cosmopolitan species first found in Hawaii by Koebele; I do not know the date of his earliest collections, although they were made probably before 1896.

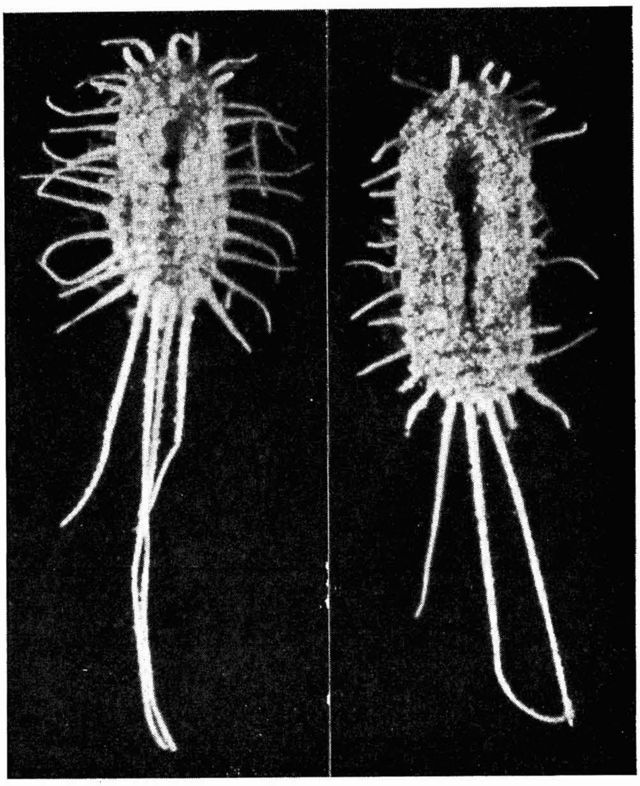


Figure 101—*Pseudococcus adonidum* (Linnaeus), the long-tailed mealybug. These examples are dried and the bodies are shriveled.

Hostplants: banyan (*Ficus*), *Caladium*, *Canthium odoratum*, *Codiaeum variegatum*, *Cordyline terminalis* ("ti"), *Epidendrum*, ferns, *Ficus bengalensis* (on the aerial roots), *Hibiscus*, *Myoporum*, pineapple, *Tetraplasandra* and many kinds of orchids, upon which they are important pests.

Parasite: *Anagyrus nigricornis* Timberlake (Hymenoptera: Encyrtidae).

Predator: *Sympherobius barberi* Banks (Neuroptera: Hemerobiidae).

This is sometimes a pest of greenhouse plants. The bodies of the adult females range from pale yellow to grayish in color. The lateral wax filaments are between one-fourth and one-half as long as the breadth of the body, but the caudal filaments are unusually long and may be as long as or longer than the body, or between 3.5 and 4.0 mm. in length; there is a total of 17 pairs.

The following notes are by Ferris:

This species is readily recognizable, even among the several forms of closely similar type, by the following combination of characters:

Both anal lobe and penultimate cerarii are each surrounded by a conspicuous and strongly sclerotized area, the area on anal lobe being somewhat elongate while that about penultimate cerarius is smaller and more or less circular. Conical setae of anal lobe cerarii quite large and stout, those of next cerarius somewhat smaller. Pores of anal lobe cerarius concentrated into a dense cluster, forming a somewhat depressed area about conical setae. Those of penultimate cerarius, while quite numerous, are fewer and not so markedly concentrated. On ventral side of anal lobe there is a very distinct, sclerotized area of somewhat triangular form, extending in from base of anal lobe seta, and mesal border of this area shows a densely sclerotized, narrow marginal strip. Dorsum of body bearing a small number of quite large tubular ducts, each with a distinct oral rim. A distinctive feature is the presence of two or, more commonly, three of these ducts close to each cerarius, two of these in each set being smaller than the other. Multilocular disc pores very few, confined to immediate region of vulva.

The numerous specimens of this species which are available from many parts of the world adhere very closely to the pattern described above, and nothing has been seen that raises any doubt concerning the species.

The only problems connected with the species are nomenclatorial. They need not be recited in detail other than to remark that the identification of this species with the *Coccus adonidum* of Linnaeus rests merely upon a sort of traditional interpretation of the species.

Pseudococcus antricolens Ferris, new species (figs. 102, 103).

Host and locality: From *Santalum freycinetianum* on the Palolo–Waialae Ridge, Oahu, Hawaii, August 15, 1945, K. Sakimura, collector, and a large series from the same host and general area taken by E. C. Zimmerman.

Habit: Occurring in deep, pouch galls on the leaves of the host. From the material examined it would appear that at least two and perhaps three generations are produced within the same gall, since in some of the galls there would be found

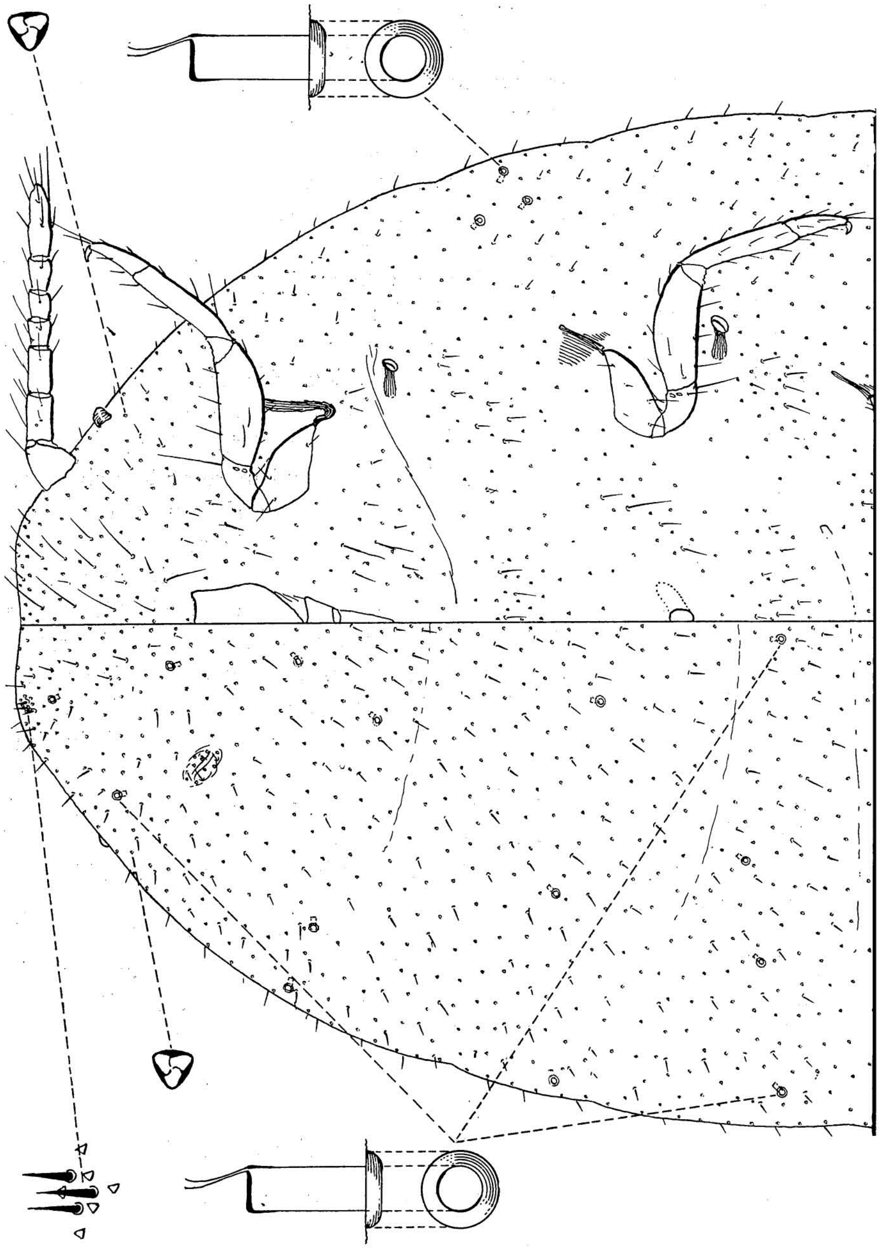
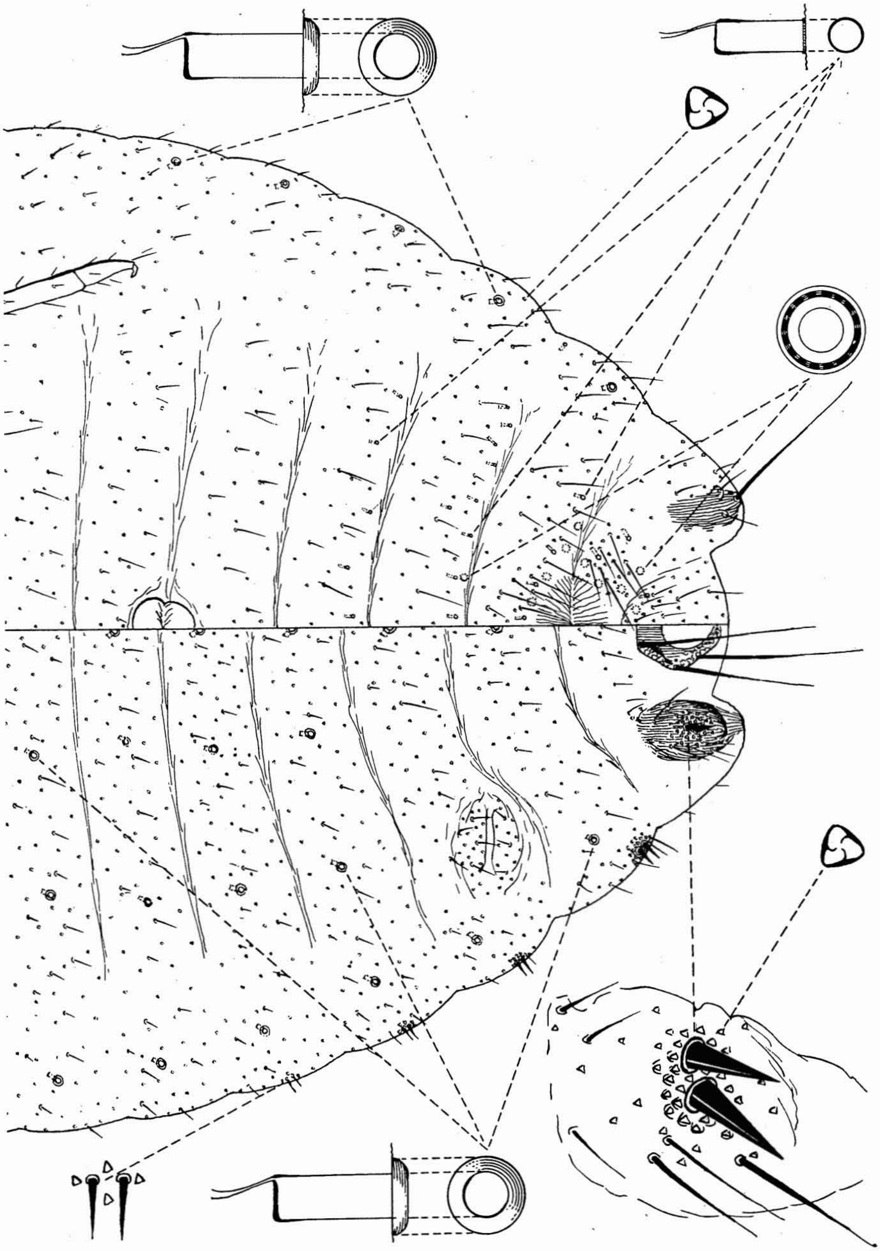


Figure 102—*Pseudococcus antricolens* Ferris, new species. (Drawn by Ferris.)



a single individual, usually parasitized, accompanied by several other individuals of which part were mature and others very young. The percentage of parasitism seems to be quite high.

Recognition characters: Length of non-gravid adults, on slides, about 1.75 mm., it thus being a quite small species. Antennae, in two complete prepared specimens, seven-segmented. Circulus present. Cerarii reduced in number, there being but five pairs on abdomen and a frontal pair on head. Anal lobe cerarius with two quite large, conical setae and several slender setae, conical setae surrounded by a closely set group of pores, whole area enclosed within a definitely defined sclerotization and bearing but few pores other than central cluster. Penultimate cerarius with two smaller conical setae, three or four slender accessory setae and a cluster of pores. Anterior to this the cerarian setae become smaller, with fewer pores and with at most but one or two slender setae and a very few pores. Frontal cerarius with two or three very small, conical setae and but four or five pores. Dorsal side of body very sparsely beset with setae of varying sizes, but all very small. Dorsum with moderately large tubular ducts each with an oral rim, there being normally one such duct just in from each abdominal cerarius or just in from margin on abdominal and thoracic segments where cecarii are lacking, with a few others scattered over dorsum, as far forward as head. Ventral side of anal lobes with a distinct sclerotized area extending in from base of anal lobe seta. Multilocular disc pores very few, there being a total of scarcely more than 20, these confined to area immediately about vulva. A single tubular duct with an oral rim, similar to those of dorsum, occurs just in from lateral margin on most of abdominal segments and two or three such ducts appear in area just laterad of middle coxa. Very small tubular ducts, each with a very slight collar, occur in extremely small numbers in median region of venter from terminal segment to third segment anterior to vulva. Ventral setae very sparse and even the longest being quite small. Trilocular pores quite sparse over entire body, both dorsally and ventrally. Legs quite small and short.

Notes: Since this species is a gall-maker, the natural impulse is to regard it as identical with *gallicola*. However, the available specimens indicate the presence of two gall-making species which, while closely similar, appear on the basis of present information to be distinct. This species differs from *gallicola* definitely in its seven-segmented antennae and in the well-defined sclerotized area about the anal lobe cerarii. Other slight differences, such as the shorter legs, the fewer cerarii and the somewhat greater number of small tubular ducts on the venter, may very well be within the range of normal variation. (The foregoing material is by Ferris.)

The holotype slide is in the Bishop Museum.

The long, slender, finger-like, contorted galls of this species are conspicuous on the leaves of their sandalwood host. They are conspicuously different from those of *gallicola* as that species is here interpreted. I have found them abundant on occasion in the southeastern Koolau Mountains and have seen what appears to be the same gall from the same host at the opposite end of the mountain range. Nearly all galls protrude above the upper surface of the leaves and the leaf is

usually deformed and notched from the margin to or toward the base of the galls. The galls may attain a length of 8 mm. and be 1 or 2 mm. in diameter. Mites were also found in some of the galls I have opened.

A mealybug examined alive measured 1.2 mm. long by 0.5 mm. broad. The pair of long caudal filaments was 1.0 mm. long, the short outer filaments (one at outer side of each long caudal filament) were 0.2 mm. long, and the pair of minute median filaments was 0.1 mm. long. Body color yellowish, meal coarse, white; no dorsal markings of any kind, or with a darker pinkish median coloration showing through. When disturbed, the abdomen is flipped upward in a series of jerks.

The symbiont picture in the mycetome of this species is distinct from that of specimens of what we have called *gallicola* from Maui.

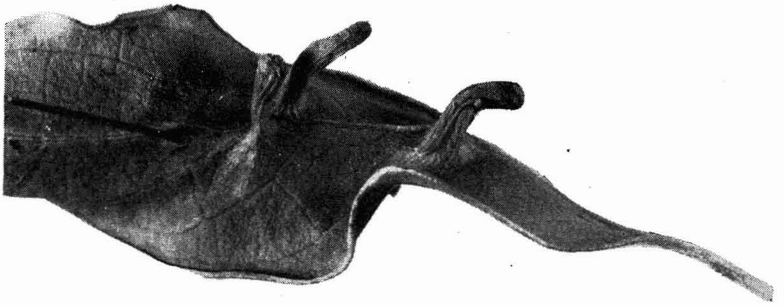


Figure 103—Galls made by *Pseudococcus antricolens* Ferris on leaf of *Santalum freycinetianum* (the leaf had dried before the photograph was taken).

Pseudococcus boninsis (Kuwana) (figs. 104, 143).

Dactylopius (*Pseudococcus*) *boninsis* Kuwawa, 1909:161, pl. 10, figs. 4–5.
Morrison, 1925:489, figs. 2, 3; redescription and discussion.

The gray sugarcane mealybug.

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. A nearly tropicopolitan species, and its range extends into the lower temperate zones. Evidently first brought to notice in Hawaii by Koebele, but I do not have an exact record of the date of its earliest capture. It probably was accidentally imported with sugarcane at an early date. It was originally described from sugarcane from the Bonin Islands.

Hostplants: *Eragrostis variabilis* (this record should be checked), sugarcane.

Parasites: *Aphycus terryi* Fullaway, *Xanthoencyrtus fullawayi* Timberlake, *Coelaspidia osborni* Timberlake (Hymenoptera: Encyrtidae).

Predators: *Cryptolaemus montrouzieri* Mulsant, *Scymnus debilis* LeConte (Coleoptera: Coccinellidae); *Gitona perspicax* (Knab) (Diptera: Drosophilidae).

This species may at times become abundant beneath the bases of sugarcane leaf sheaths. Its body is gray, and it has about a half dozen short lateral wax processes and two pairs of longer, thicker, anal filaments. It is smaller, less plump and more slender than the pink sugarcane mealybug with which it frequently occurs. The

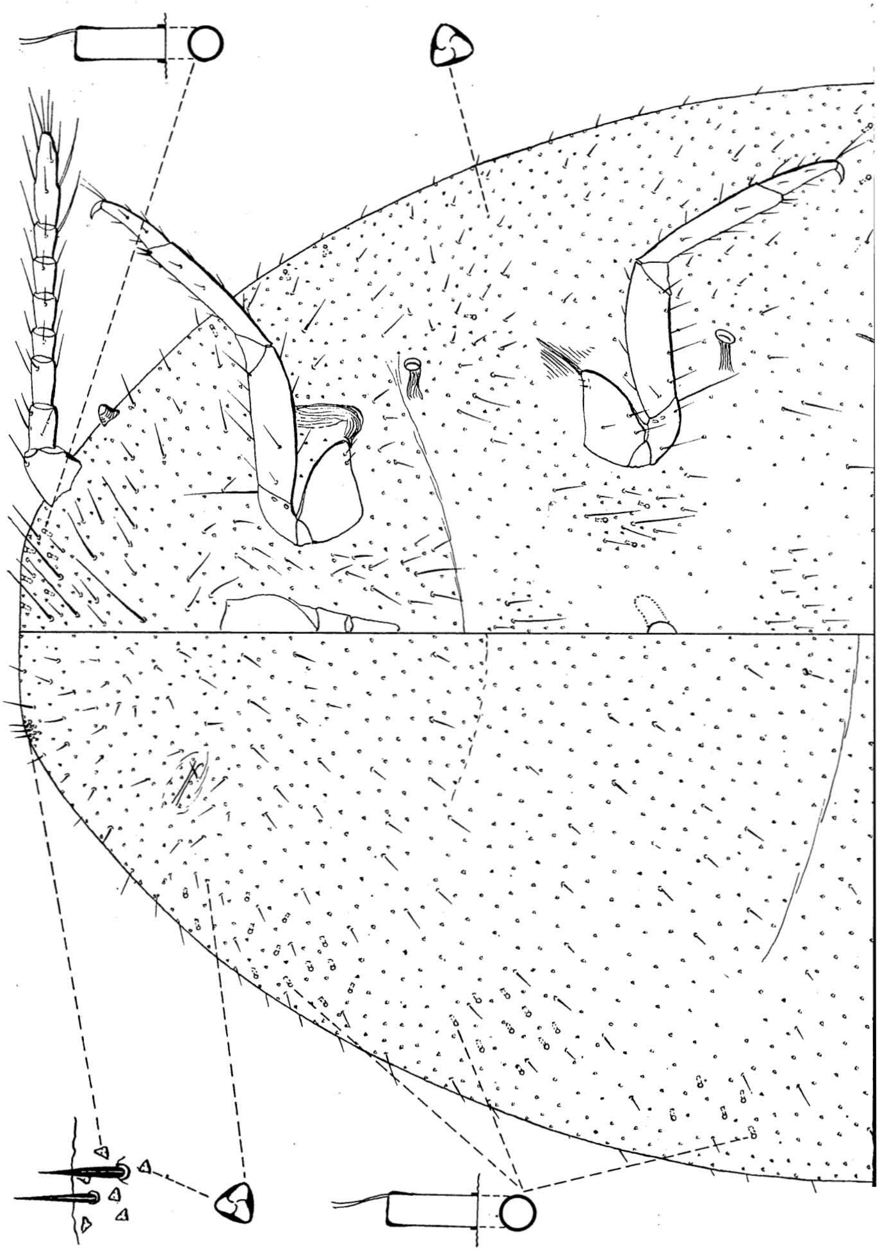
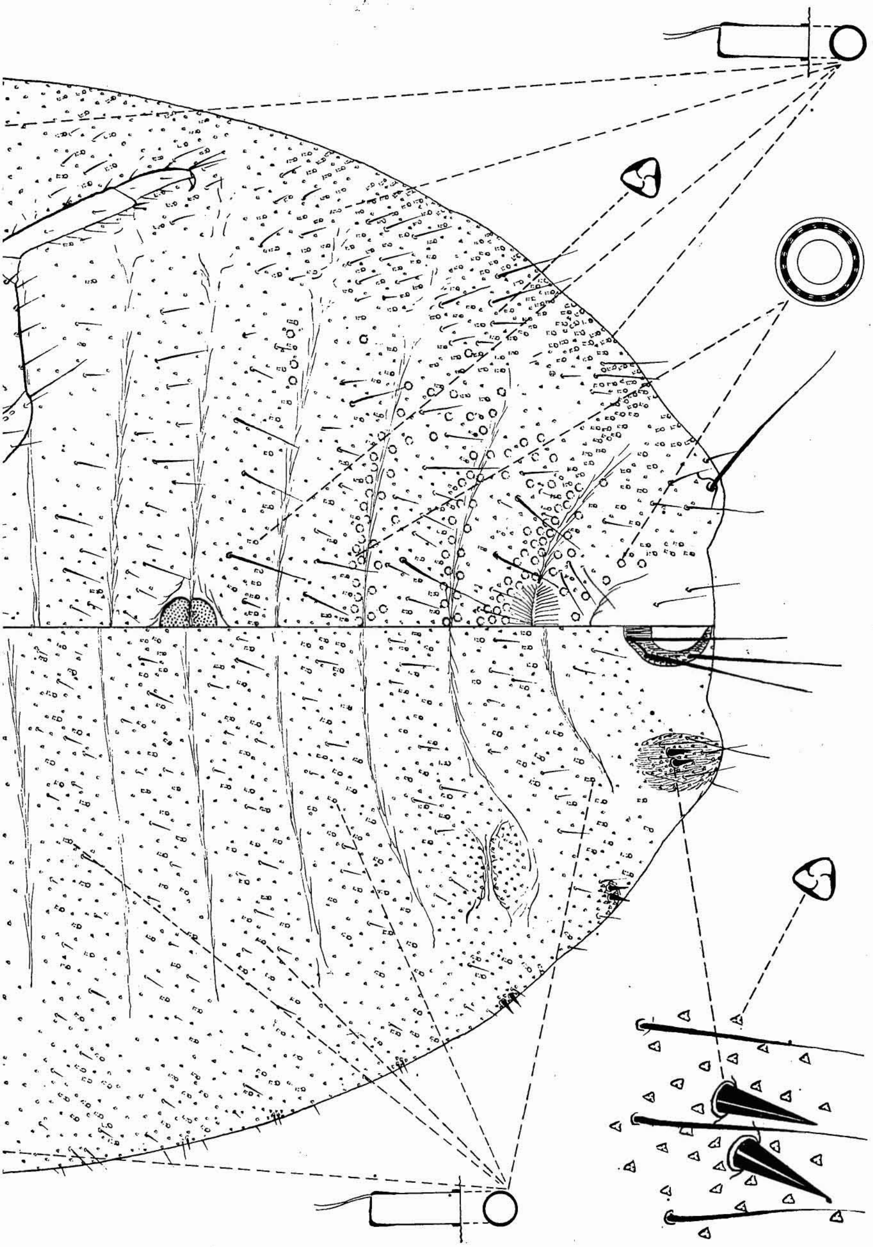


Figure 104—*Pseudococcus boninsis* (Kuwana), the gray sugarcane mealybug. (Drawn by Ferris.)



yellowish eggs are enclosed in a fluffy eggsac, and they "hatch in 10 days or less and the development of the active young to maturity requires from 18 to 26 days more, according to sex, the female taking the longer time." (Williams, 1931:113.)

It was formerly more numerous and caused damage, but it is so well controlled by parasites and predators as to be generally uncommon now. It is not so fecund as is the pink sugarcane mealybug, for Swezey (1913:204) found that an average of 135 eggs per female was produced.

There has been considerable confusion in the name of this species as used in Hawaiian literature. It has at various times and by different authors been called *Dactylopius calceolariae* Maskell, *Pseudococcus calceolariae* (Maskell), *Trechocorys calceolariae* (Maskell), *Pseudococcus sacchari* (Cockerell) and *Pseudococcus saccharifolii* (Green). Morrison (1925:485) has given detailed and helpful notes, descriptions and illustrations of the group of species involved in this complex. *Pseudococcus saccharifolii* (Green) has the posterior abdominal cerarii with about eight spines in each, whereas *calceolariae* (Maskell) and *boninsis* (Kuwana) have normally only two spines. *P. calceolariae* has 17 pairs of cerarii, but *boninsis* has only one pair on the head and five or six on the posterior part of the abdomen.

Ferris has contributed the following text:

The generic position of this species is somewhat doubtful. The reduced number of cerarii suggests an assignment to *Trionymus* but the circulus is not typical of that genus, since it extends across the intersegmental line and is divided by a transverse fold. For the present it may as well rest in *Pseudococcus.*

Among the species known from Hawaii and which are referred to *Pseudococcus,* it may be recognized by the following characteristics:

Number of pairs of cerarii reduced, a maximum of one pair on the head and six pairs counting forward from the anal lobes. Furthermore, the cephalic pair is at times lacking and at times only four or five abdominal pairs are recognizable. Anal lobe cerarii each with two quite stout conical setae and five or six slender setae set in a rather faintly but definitely sclerotized area in which the trilocular pores are numerous but only slightly concentrated about the conical setae. Penultimate cerarius with similar, but smaller, conical setae and a similar cluster of pores. The next has the conical setae still slightly smaller and the remainder become successively smaller until the setae of the sixth, if present, are very small. Tubular ducts throughout, both dorsally and ventrally, of a single type, varying somewhat in size but all relatively small, each with a slight oral collar but none with an oral rim. These ducts are abundant on the dorsum of the abdomen and are present in submarginal groups on the dorsum of the thorax. On the ventral side a few are present on the head between the antennae, occasionally on the venter of the thorax and in considerable numbers in the submarginal areas of the abdomen and across the segments posterior to the circulus. Multilocular disc pores confined to the venter of the abdomen, present about the vulva and on the segments forward to the circulus. Antennae normally eight-segmented, but sometimes seven-segmented and quite variable.

The accompanying figures are based upon specimens from the Bonin Islands received from S. I. Kuwana.

Pseudococcus brevipes (Cockerell) (figs. 105–113, 143).

Dactylopius brevipes Cockerell, 1893:267, fig. 1.

Coccus bromeliae Bouché, Naturgeschichte des Insekten, p. 20, 1834 (I have not seen this reference). Bouché's name *bromeliae* is a homonym, hence the use of Cockerell's later name.

The pineapple mealybug.

Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.

Immigrant. A nearly cosmopolitan species, described from Jamaica; occurs in the open over most of the tropical and subtropical parts of the world. Although in all probability an early immigrant to the Territory, this species does not appear to have been noticed in Hawaiian literature until Kotinsky published his local record in 1910 (p. 127).

Hostplants: banana, various bromeliads, canna, celery, *Chloris inflata,* coffee, cotton, *Cyperus rotundus* (nutgrass), *Euphorbia, Gliricidia,* Hilo grass, Natal grass, orchids, *Panicum, Pennisetum purpureum,* pineapple, *Portulaca, Sida,* sisal, soursop, *Straussia* and a long list of other plants, a detailed report of which has not been published to my knowledge.

Parasites: *Anagyrus* (a new species, description by Gahan now in press, previously listed in our literature as *coccidivorus* Dozier), *Leptomastidea abnormis* (Girault), *Hambletonia pseudococcina* Compere, *Aenasius colombiensis* Compere, *Aenasius cariocus* Compere (Hymenoptera: Encyrtidae). The two species of *Aenasius* were released, but evidently they have not become established here.

Predators: *Scymnus pictus* Gorham, *Scymnus* (*Pullus*) *uncinatus* Sicard, *Cryptolaemus montrouzieri* Mulsant, *Nephus bilucernarius* Mulsant (Coleoptera: Coccinellidae); *Lobodiplosis pseudococci* Felt (Diptera: Cecidomyiidae) (on occasion, this fly gives good control).

The adult females resemble those of *citri* but are more plump and convex, and they are ovoviviparous instead of oviparous. They are secretive in habit and are usually found near the bases or undersides of the leaves of such plants as pineapple, or at the bases or roots of plants. The lateral wax processes are usually less than one-fourth as long as the breadth of the body, the caudal ones between one-third and one-half as long as the body. There are 17 pairs of wax filaments. When the body is mashed, the juices are brownish-orange in color.

Seventeen pairs of cerarii present, all with a slight concentration of pores and with accessory setae, but with the number of conical setae variable. The commonest arrangement is as follows: Anal lobe cerarius always with only two conical setae. Abdominal cerarii anterior to this with two conical setae of same size and one to as many as four smaller conical setae, the number of cerarii with these additional setae and the number of setae in any one cerarius being variable. Along thoracic margin there are usually but two conical setae in each cerarius and then in head region—as is common in many species—each cerarius may have three or four conical setae of same size. There are no sclerotized areas about any cerarii. Ventral side of anal lobes with a sclerotized area of variable size and form, but always present. Dorsum of body entirely without tubular ducts. Small ducts with a slight oral collar are present ventrally in considerable numbers along posterior

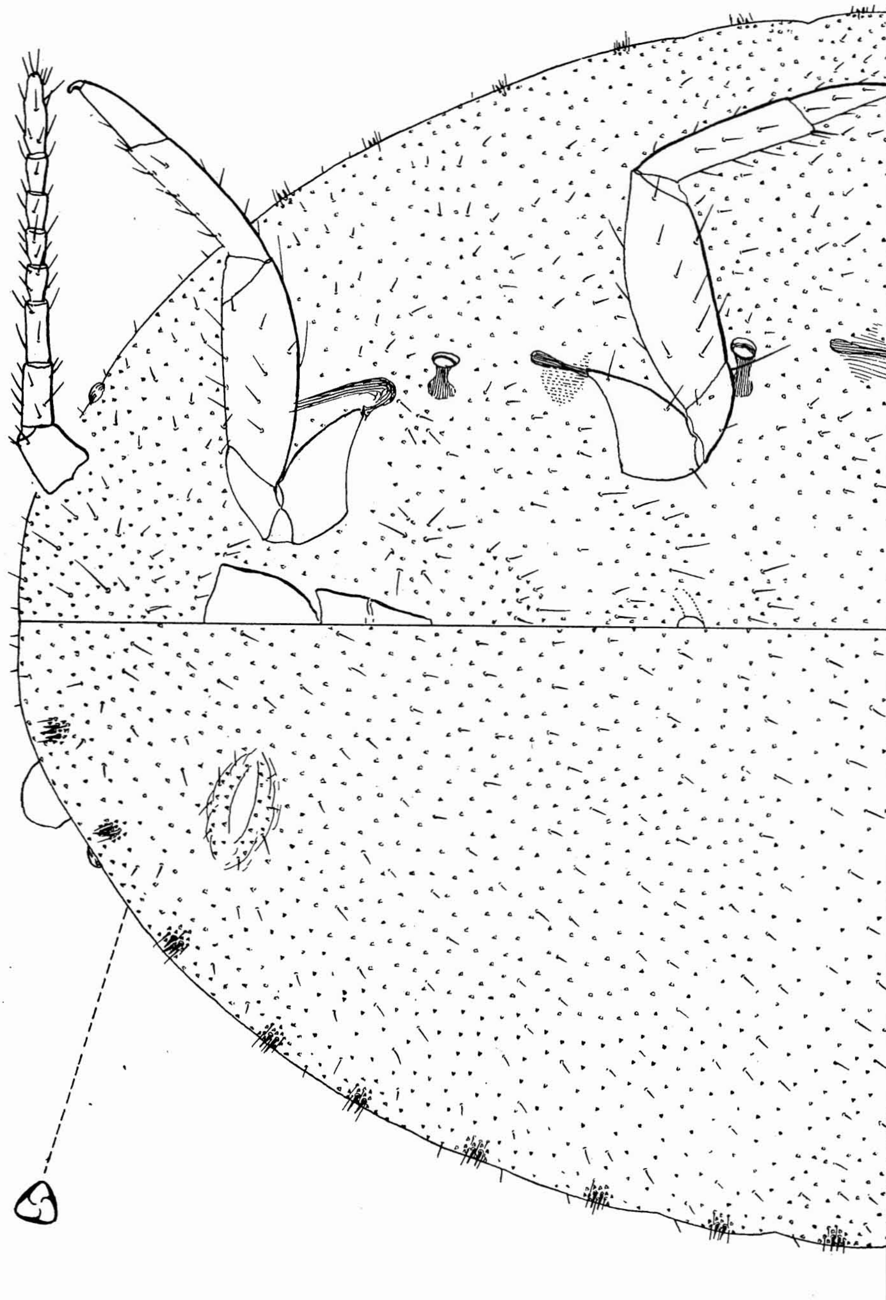
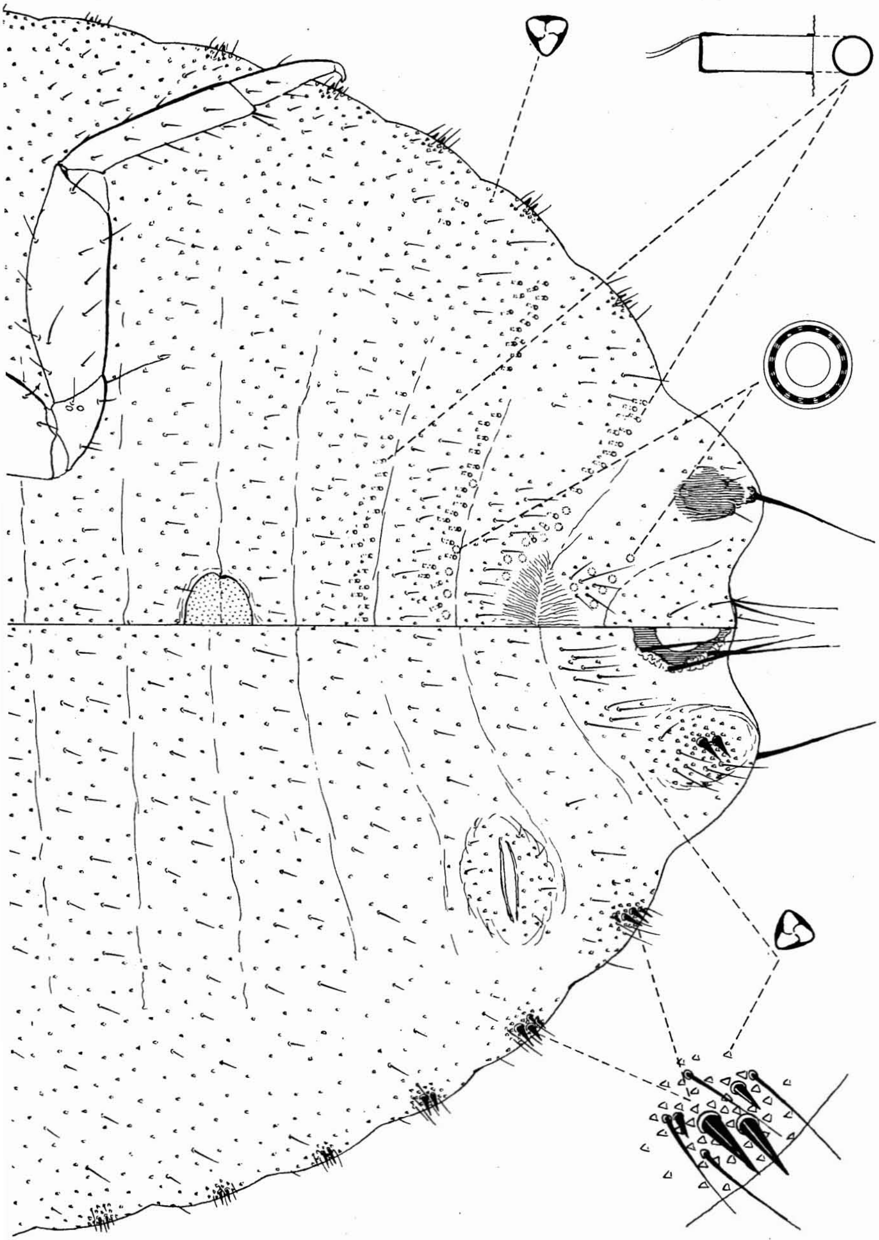


Figure 105—*Pseudococcus brevipes* (Cockerell), the pineapple mealybug. (Drawn by Ferris.)



border of segments between vulva and circulus and in small numbers near lateral margins. Multilocular disc pores few, restricted to segments immediately about vulva. Circulus present.

Specimens from many hosts and many lands, including Hawaii, have been available for examination. While there is a considerable degree of variation in these specimens, they all adhere to the general pattern described above. The accompanying figures are based upon specimens from pineapple, Gold Coast, Africa. (The two paragraphs above were contributed by Ferris.)

This is economically the most important coccid in the Hawaiian Islands because of its involvement in diseases in pineapples. Many hundreds of thousands of dollars have been spent in studying and controlling it. A large mass of published data has been assembled, and a great deal of research work has been carried on, but the species continues to be by far the most serious insect pest of pineapple in Hawaii. The fight against it is intimately tied in with the control of its principal attending ant, the notorious, tropicopolitan *Pheidole megacephala* (Fabricius).

Unlike some well-known coccid pests, this species has not yielded to biological control. Carter (1942:14) stated that

> The prospects for effective biological control of *Pseudococcus brevipes* do not seem to be bright, for out of 14 species of parasites and predators introduced and released in the fields in Hawaii during the past 11 years, only the cecidomyid *Lobodiplosis pseudococci* Felt is even partly effective and that only on infested fruits. This is contrary to the experience with many other species of mealybug and can best be explained by reference to the effective and constant protection offered *P. brevipes* colonies by ants. The evidence that several strains of *P. brevipes* exist raises one technical question which probably must remain unanswered, namely, were any of the six species of internal parasite thus far found on *P. brevipes* and liberated in Hawaii, collected from strains of *P. brevipes* identical with the Hawaiian strains?

Carter (*Proc. Hawaiian Ent. Soc.* 12(1):15, 1944) makes the following observations:

> The abandonment of ratoon pineapple fields due to labor shortages has resulted in many areas where mealybug populations on the developing ratoon fruit have reached a considerable size. At the same time the fields have become very weedy. Under these circumstances, biological control of *P. brevipes* has been sufficient to almost completely eliminate the insect from the fruit. The principal factor operating is undoubtedly *Lobodiplosis pseudococci* Felt. ... Many fruits can be found plastered with the old webs of this insect, with no mealybugs left alive on the fruits.
>
> With such control evident, it is interesting to speculate on why biological control of the mealybug is not more generally successful. First among the possible reasons is the establishment of large populations on fruit. The midge is rarely found on leaves, possibly because the mealybugs on leaves keep moving down into the dark center of the plant, as the leaves grow. On the other hand, mealybugs on the bases of fruits are more sessile and give opportunity for the midge to establish its web over the developing female mealybug. Second is the fact that in a weedy field, *Pheidole* ants are apparently more independent of mealybugs for food, and their attendance on the mealybug is not as close as normally.
>
> Unfortunately, even in these fields where the mealybugs on fruit are practically wiped out, residues of the populations are to be found on all the developing suckers in the vicinity of the infested fruits. These colonies are untouched by the midge, and it is these colonies which will cause mealybug wilt in the developing suckers. It is clear that no biological factor can operate to prevent mealybug wilt unless it is capable of reducing populations of mealybugs on young, unfruited plants, well attended by ants.

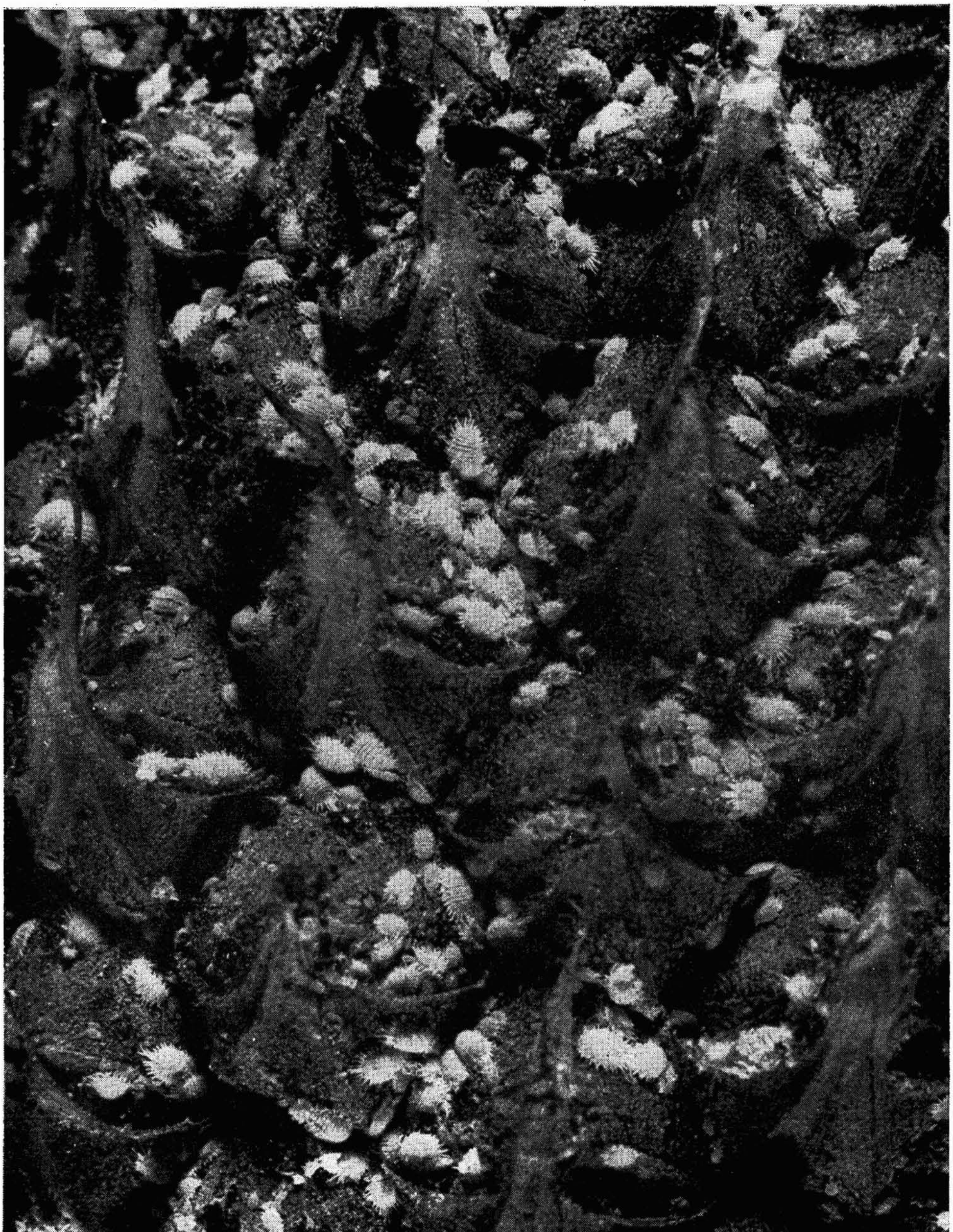


Figure 106—A typical infestation of *Pseudococcus brevipes* (Cockerell), the pineapple mealybug, on an immature pineapple fruit.

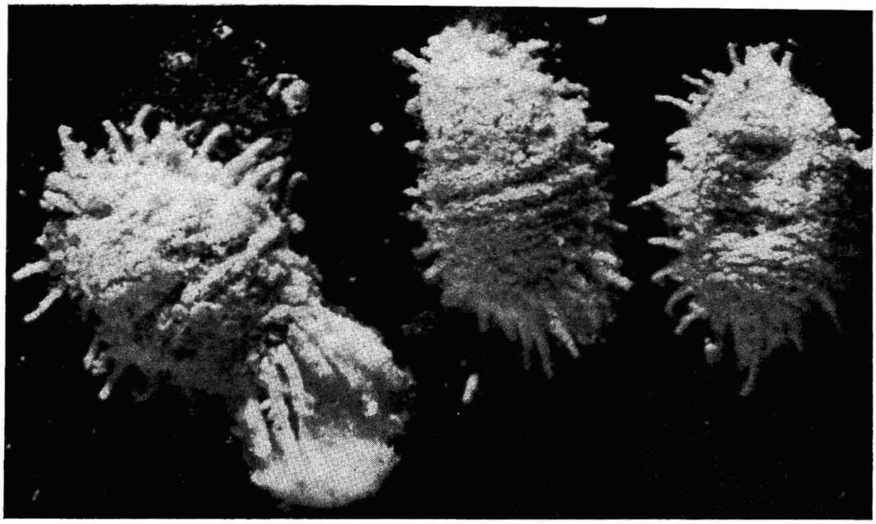


Figure 107—*Pseudococcus brevipes* (Cockerell), the pineapple mealybug. The example at the left has a brood of young under the cottony mass at the hind end of her body.

A confusing situation exists in regard to the Hawaiian *brevipes* populations in that two "strains" are known to occur. Individuals of one of these strains produce green spotting on pineapple leaves, those of the other do not. The green-spotting individuals are predominantly grayish in color (their bodies are really brownish, but in combination with the white waxy exudation they assume a grayish color), but those which do not cause green spotting are mostly pink. Detailed studies of these two "strains" have failed to show morphological differences. However, the life histories of the two forms are distinct. The pink form reproduces parthenogenetically and gives rise to females only. The gray, or green-spotting, form reproduces sexually with males produced among the offspring.

The females of both forms moulted three times before reaching maturity. The average number of progeny produced by 64 pink females was 234 and by 20 gray females was 347. The average length of life of the pink females was 90 days; of the mated gray females 95 days; and of 39 unmated gray females 148 days. The males moulted four times before reaching the winged, adult stage. They fed only during the first and part of the second instar. They lived for an average length of 37 days. The winged adults spent an active life of about two days from the time of emerging from their cocoons until death. (Ito, 1938:297.)

Some females give rise to nearly a thousand crawlers.

The following information has been abstracted mostly from papers by Carter (1932, 1933, 1936). These papers should be consulted by anyone seeking detailed information on the subject.

Mealybugs become established on the pineapple planting material during growth. These individuals persist on the future plant sets while they are partially dried after trimming and can, on occasion, even reproduce on this detached material. Hence, a newly planted field may have a large initial mealybug population. How-

Figure 108—Aerial photograph (by U. S. Army) of pineapple fields showing typical invasions of mealybug wilt (pale areas) especially prominent at edges of the fields. See the text for discussion. (Photograph loaned by Walter Carter, Pineapple Research Institute.)

ever, peculiar as it appears, most of these populations disappear either because of the lack of adequate attending ant populations or because of predator pressure or other causes. The serious infestation of a new field comes from outside, adjacent areas, especially old pineapple fields, waste or uncultivated lands. High infestations may build up from the outside within a period of six months. This movement is dependent primarily upon the action of the attending ant *Pheidole megacephala*. If the ant populations are low, the subsequent mealybug invasion of the fields will be slow and of low grade. If the ant could be eliminated, the fields would be largely free of serious mealybug infestation. Ants are essential for the proper development of mealybug colonies, for they tend them, shelter them, protect them from parasites and predators and keep them clean from detritus which, when massed with honeydew, has a gumming-up and deleterious effect on the colonies. In short, pineapple mealybugs have a difficult time maintaining themselves unless ant-attended.

The damage done to the pineapple plants is of two major types: one is pineapple wilt, now called mealybug wilt (also referred to as edge-wilt because it appears first at the edges and borders of fields and around the edges of rock piles and other non-planted areas because these areas are first infested with new mealybug populations), and the second is green spot. Of these, mealybug wilt is the more serious.

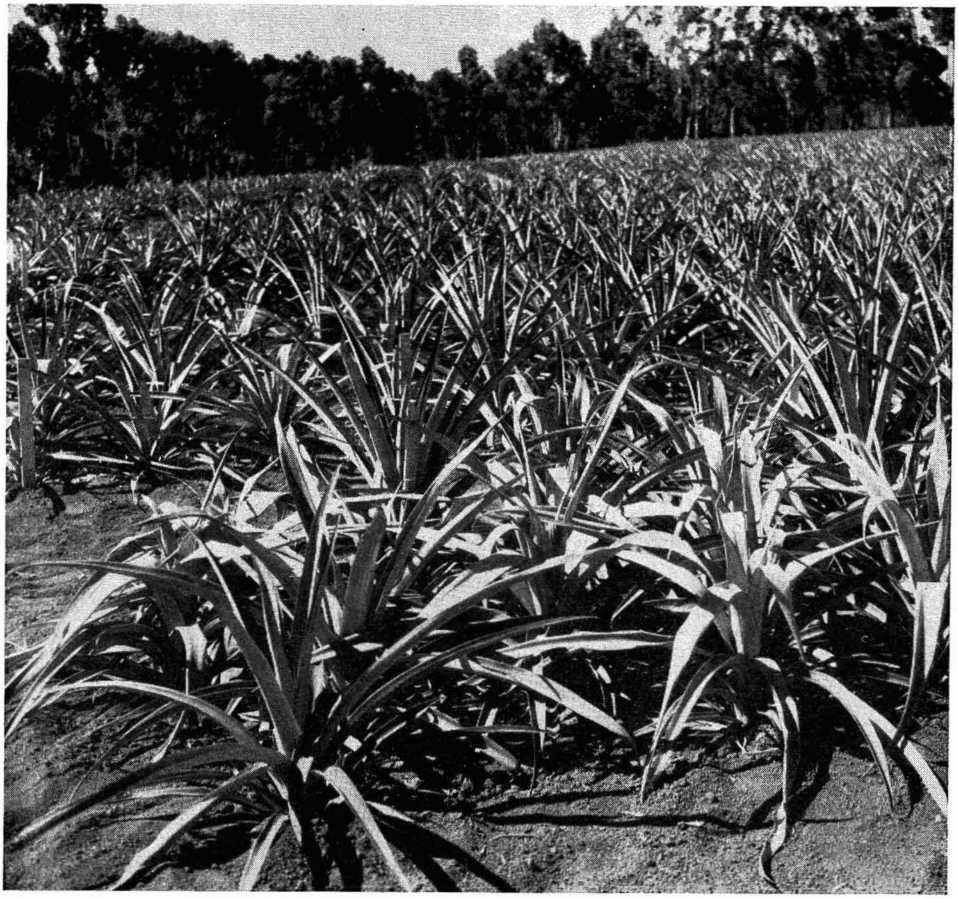


Figure 109—Mealybug wilt in young pineapple plants (foreground) ten weeks after infestation with *Pseudococcus brevipes* (Cockerell). (Photograph courtesy Walter Carter, Pineapple Research Institute.)

Ordinary feeding by non-green-spotting mealybugs, especially prolonged feeding in one area by a group of mealybugs, will, because of the exhaustion of cell contents in underlying areas, produce chlorotic areas of delimited expanse. However, green spotting is of an entirely different nature. "It appears to have a definite developmental history, beginning as a zone of hyperactivity, continuing as an area in which the chloroplasts are larger and more numerous, and ending as a welt-like simulation of a gall. Its zonate character indicates diffusion, perhaps of specific secretion components, outward from the darker center of the spot." (Carter, 1933: 256.) Green spotting has not been produced by mechanical inoculation, and mealybugs of the pink, non-green-spotting forms do not induce green spotting in healthy plants even after prolonged feeding on heavily green-spotted plants. The ability to cause green spotting is an inherited quality, for larvae born of green-

Figure 110—Mealybug wilt of ratoon pineapple crop. Note the severe collapse of the lower leaves especially. (Photograph loaned by Walter Carter, Pineapple Research Institute.)

spotting parents are capable of causing green spotting on the first plant upon which they feed. Thus, "green spotting is not the result of infection of the plant by a specific organism but is, rather, a response by the plant to a secretion of the mealy bug, which is specific to certain individuals and not common to the species." (Carter, 1933:257.) Studies by Carter of the mycetomes of these strains show that the mycetomes are different in green-spotting and non-green-spotting mealybugs. "The mycetomes from definitely gray forms are brown, while those from pink forms present the normal appearance of freshly dissected white tissue. Under low-power magnification the brown mycetomes appear denser and with a more clearly defined membrane. They are less easily damaged in dissection." (Carter, 1933:258.) The contents of the mycetocytes contain two symbiotic organisms, one of which is common in both green-spotting and non-green-spotting individuals, but the other, a rod-shaped, bacterium-like form, is found in large numbers in the green-spotting forms only. (For a description of the symbionts, see Carter,

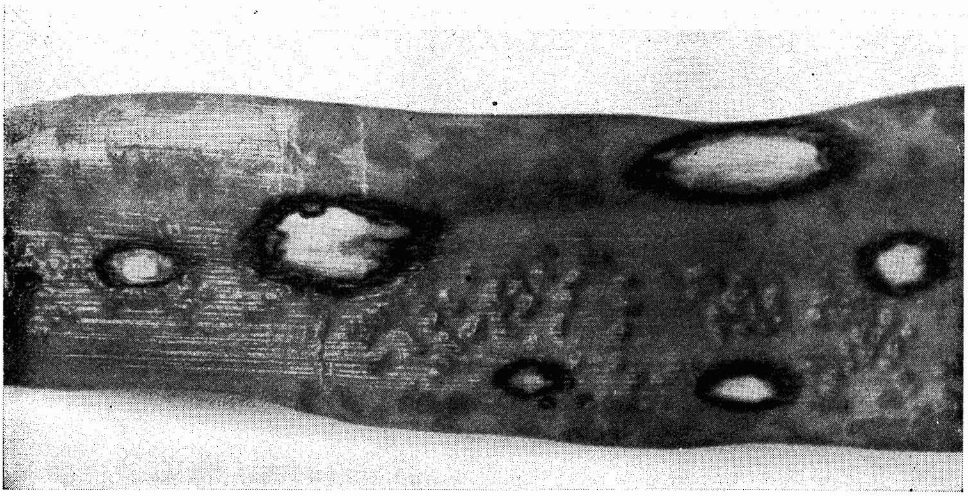


Figure 111—A section of a pineapple leaf showing effects of the feeding of green-spotting pineapple mealybugs, *Pseudococcus brevipes* (Cockerell). Note the elevated, welt-like green spots and the extensive patches of secondary necrosis. (Photograph loaned by Walter Carter, Pineapple Research Institute.)

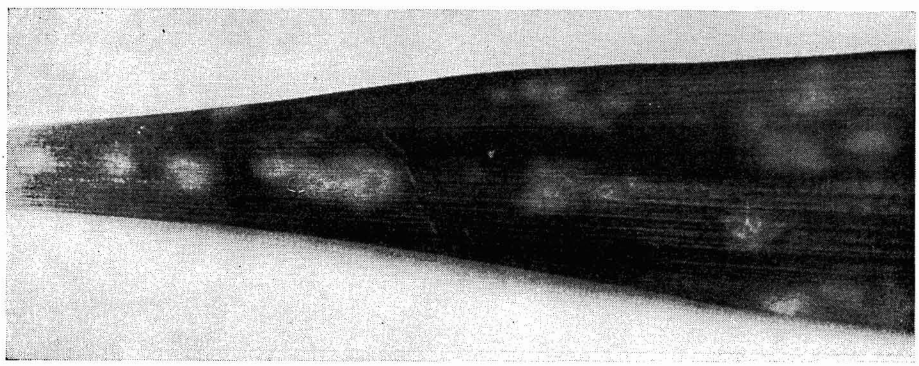


Figure 112—A part of a pineapple leaf showing chlorotic areas produced following feeding by non-green-spotting pineapple mealybugs, *Pseudococcus brevipes* (Cockerell). (Photograph loaned by Walter Carter, Pineapple Research Institute.)

1935:60.) It was first thought that there was a causal relationship between the rod-shaped symbionts and the ability of the mealybug to produce green spots, but Carter found in Africa and Singapore green-spotting strains of the mealybug which had a different symbiont mycetome flora from that of the Hawaiian mealybugs. Hence, he abandoned the theory that the green spotting was dependent upon the specific symbionts of the Hawaiian strains.

The other major pathological condition caused by the pineapple mealybug, mealybug wilt, is the principal cause of pineapple crop failure in Hawaii. The wilt attacks principally young plants. The disease is characterized by Carter (1933:211–212) as follows:

In plants up to 6 months old, the inner leaves become pale, varying from very light dull green to pale yellow or pink. With the color change is a very characteristic loss of rigidity, most of the inner leaves becoming flaccid and bending outward. The tips of these leaves turn brown and dry up. The inner leaves may show many or few or no green spots, or there may be scattered small chlorotic areas with irregular margins. With plants 8 to 10 months old, there is a conspicuous reddening of the leaves of the fourth or fifth whorl from the center with a progression of color change to red, inward, to the center whorls. From that point color changes may occur either in the direction of bright pink and yellow or to a flat yellow brown. Development of the pink and red shade is controlled somewhat by the light–shade conditions. In dense planting, the yellow and brown shades predominate. Secondary necrotic areas appear on affected leaves, presumably the result of invasion of old feeding punctures by saprophytic organisms. When quick wilt occurs at early inflorescence or fruiting stages, the general appearance is one of dried up yellow brown leaves, frequently without the outward reflexing of the leaves. Quick wilt in young suckers and slips follows the same course as in very young mother plants. This type of wilt is produced by a short period of feeding by a fairly large colony of mealy bugs.

The above is termed "quick wilt," but there is still another form of wilt which is called "slow wilt" and is described by Carter (1933:212–213) as follows:

Wilt, occurring after the development of a large colony of mealy bugs, shows fewer color changes. A most characteristic symptom on slow-wilted plants is the large number of old mealy bug feeding points. These may be of green-spotting or chlorotic-spotting types. The leaves in this type of wilt are usually so completely covered with these feeding areas as to eliminate most of the leaf tissue from functioning. The tips of these leaves are browned and dry and those of the outer leaves bend outward and droop, but there is none of the yellow pink characteristic of the quick-wilt type. The edges of the inner leaves are reflexed inward and flaccid to the touch but remain upright and retain a drab green color. Secondary necrosis is commonly encountered.

In both types of wilt the roots are collapsed, invaded by saprophytic organisms or dried up.

The following data are abstracted from Carter (1933:241): Mealybug wilt appears to be an insect-transmitted disease for which no closely parallel case is known. The evidence points to a non-living, toxic, insect secretion of variable diffusibility as the causal agent. The disease assumes many forms, dependent upon the size, time of onset of the initial mealybug population, the vigor and succulence of the plant, and the fact that recovery in various degrees is commonly encountered. Quick wilt is the type that follows a sudden attack by a number of mealybugs. Approximately two months are required for development of typical symptoms, but much longer periods are sometimes necessary. The establishment of the mealybug colony is not necessary to establish quick wilt, only a short period of feeding by the insects being sufficient. Recovery from quick wilt is commonly encountered. It is usually of no commercial significance but sometimes results in the production of small but otherwise normal fruits.

Another type of damage is of different nature. When large populations of mealybugs attack the bases of the fruits they so damage the butts that the bottom slices may be unmarketable and the attacks may cause rotting and leaking of the fruits. Still another kind of minor damage has been called "mealybug stripe" by Carter (1944:846), who reports that as a result of the feeding of mealybugs "A short section on each leaf of 3 or 4 leaves of an inner whorl is characterized by

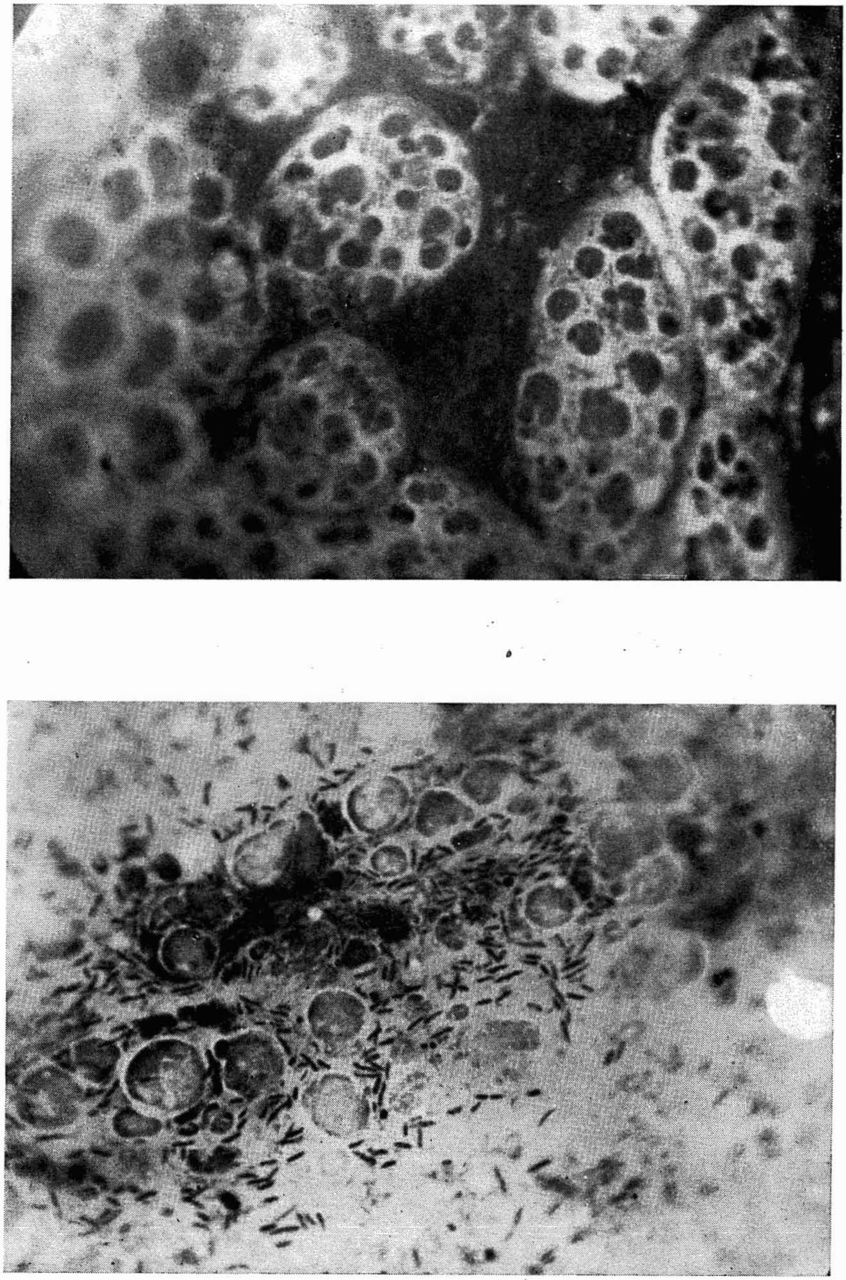


Figure 113—Photographs of mycetome smears to show some symbionts of *Pseudococcus brevipes* (Cockerell): upper figure shows mycetocytes containing the common type of symbiont (dark patches) found in both green-spotting and non-green-spotting mealybugs; the lower figure shows the rod-like symbionts of the green-spotting mealybug. (Photographs loaned by Walter Carter, Pineapple Research Institute.)

streaks of pale green to yellow and the water storage tissue in the striped area collapses." Both green-spotting and non-green-spotting strains of the mealybug produce the localized condition. "The symptom is interpreted as non-systemic but affecting a local area rather than actual feeding points, and as a specific plant reaction to the complex insect secretion different from the two types of spotting and the systematic mealybug wilt."

The dependence of mealybugs upon ants, especially *Pheidole megacephala*, in Hawaii has led to control methods which center upon the control of ants. Ant populations are greatly reduced by cultivation, but newly planted fields are invaded rapidly from adjoining areas. This led to the development of the "ant fences," which were built around pineapple fields. These consisted of boards imbedded in the soil and thoroughly sprayed with oil. These one-time characteristic features of pineapple plantations have now given way to a more efficient barrier. The movement of mealybugs into the fields along the continuous rows of pineapple plants led to the development of guard rows running lengthwise of the fields and at general right angles to the rows in the main plots and separated from them by unplanted ground. Thus, when ants and mealybugs move into these guard rows, they tend to spread along the rows around the field rather than into it. These guard rows are regularly sprayed with Diesel oil–bentonite emulsion (see Carter, 1935:268) and thus mealybug control is confined to these encircling rows. This procedure has proved so successful that it has become standard practice and is found to be essential to adequate mealybug control under present conditions.

Pseudococcus citri (Risso) (figs. 114, 116, 117).

Dorthesia citri Risso, Essai Hist. Nat. des Oranges, etc., Paris, 1813 (I have not seen this reference).

The citrus mealybug.

Oahu, Molokai, Maui.

Immigrant. A widespread species. Although listed by Cockerell in 1893 from Hawaii, much confusion exists as to the identity of the early collections. Many of the records for this species in Hawaii have been listed under *Pseudococcus kraunhiae* (Kuwana) (*Dactylopius*, Kuwana, 1902:55) because of misidentification.

Hostplants: banana (wild), *Boehmeria, Calathea*, coffee, croton, *Chrysanthemum, Ficus bengalensis*, garden bean, *Ipomoea*, mango, *Nicotiana glauca*, orange, *Pipturus*, pomegranate, *Spathoglottis pacifica, Stictocardia campanulata*, tobacco.

Parasites: *Pauridia peregrina* Timberlake, *Lepidomastidea abnormis* (Girault) (Hymenoptera: Encyrtidae).

Predator: *Scymnus notescens* Blackburn.

Ehrhorn (1916:236) described some Hawaiian material as follows: "Adult female oviparous, dull brownish yellow, marginal appendages short, of about equal length, those of caudal lobes longer. Eggsac more or less spherical. Eggs amber yellow."

This species somewhat resembles *Pseudococcus brevipes;* it is an egg-layer, but *P. brevipes* is not.

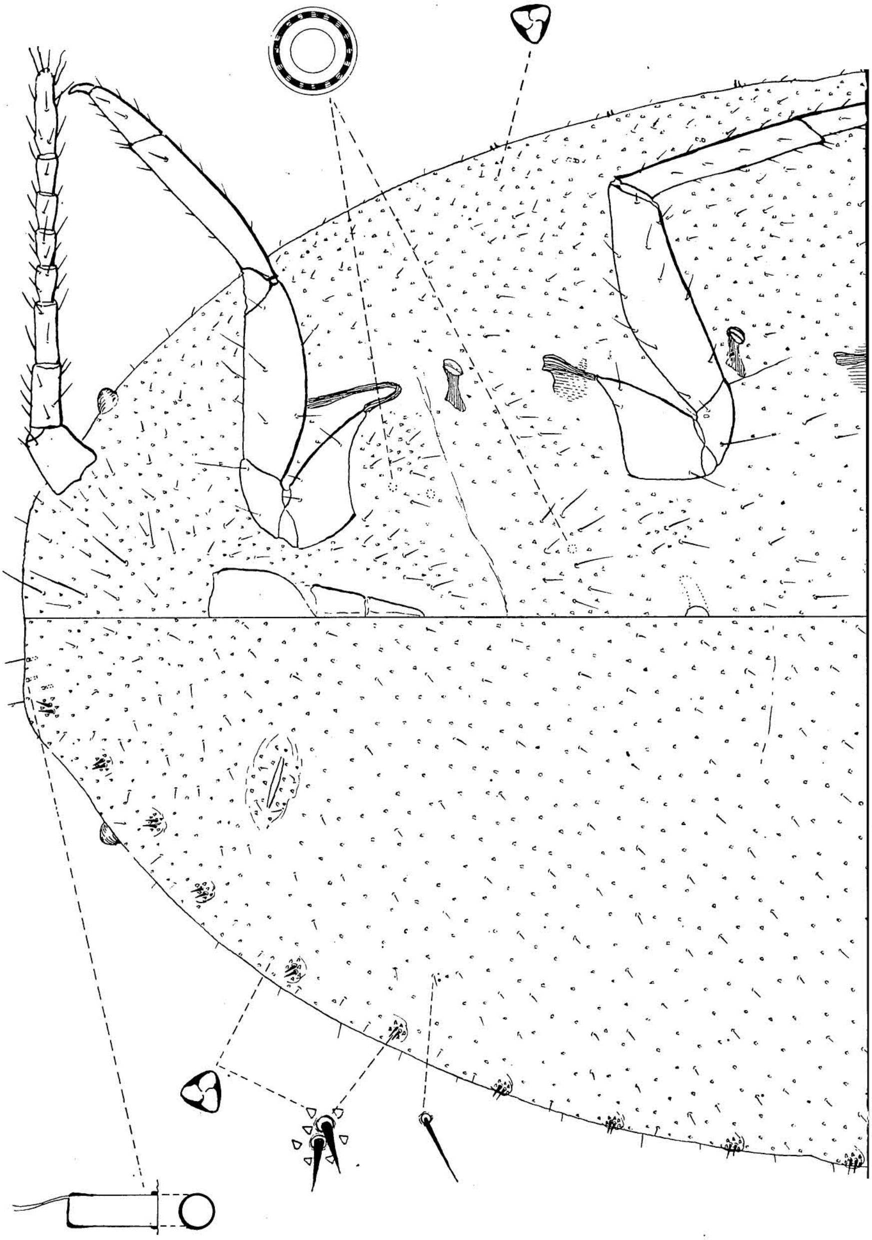


Figure 114—*Pseudococcus citri* (Risso), the citrus mealybug. (Drawn by Ferr

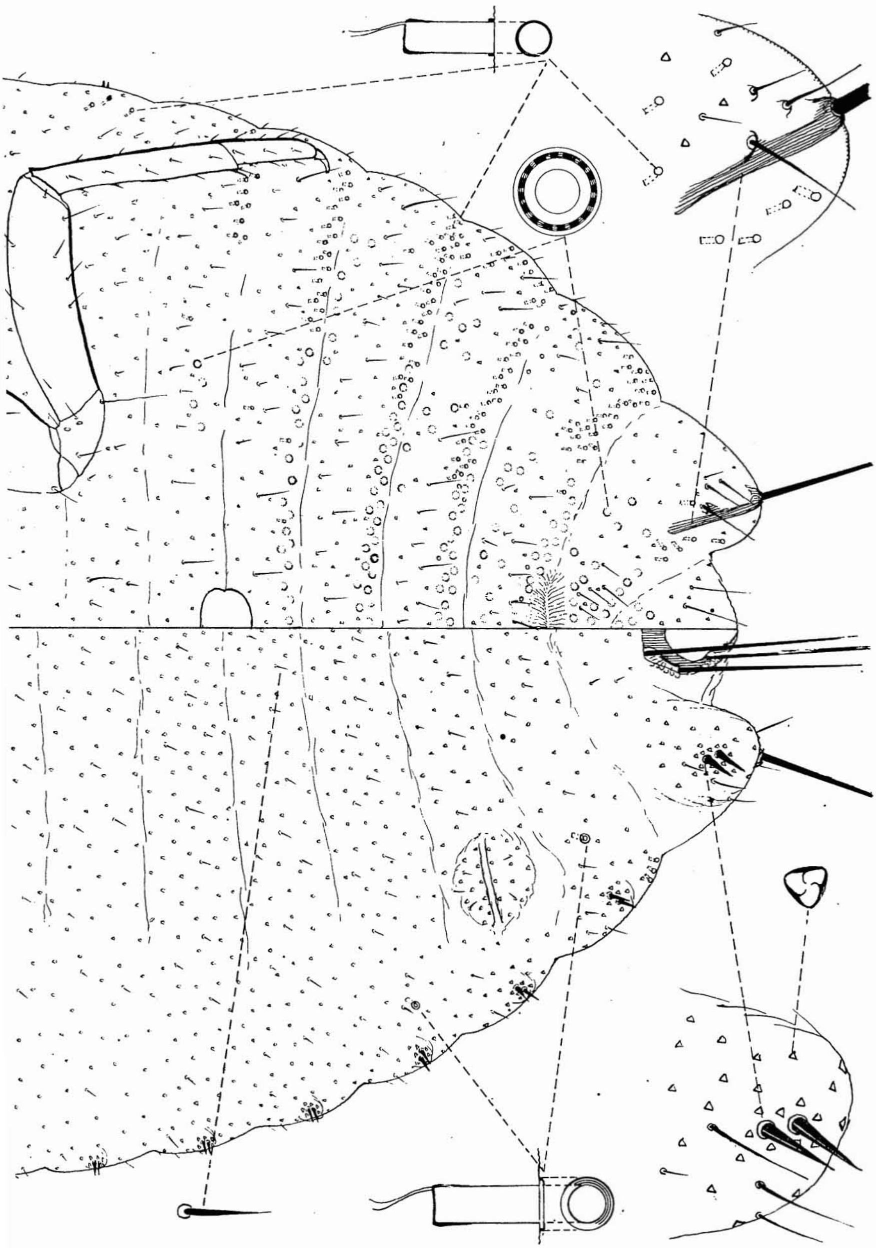
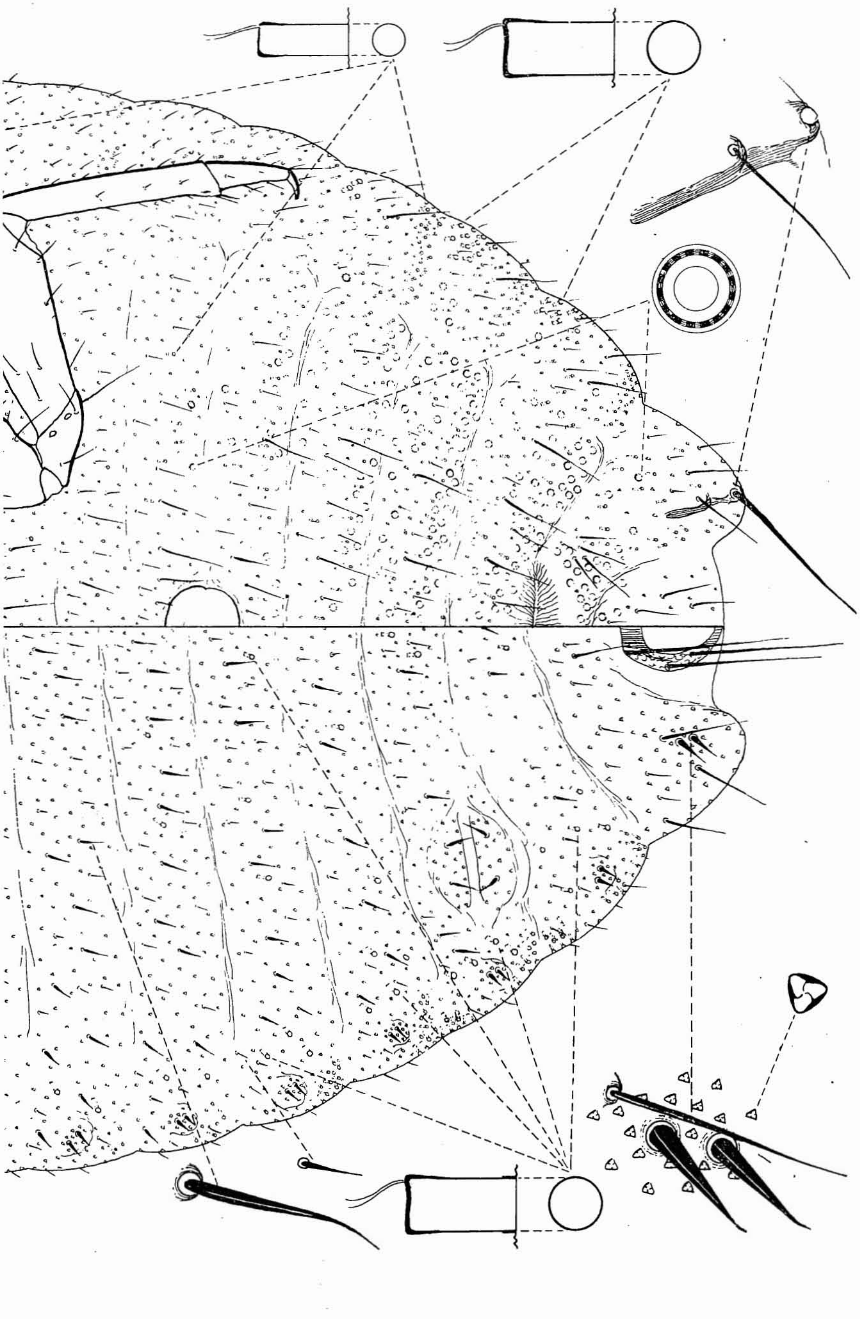


Figure 115—*Pseudococcus kraunhiae* (Kuwana). (Drawn by Ferris.)



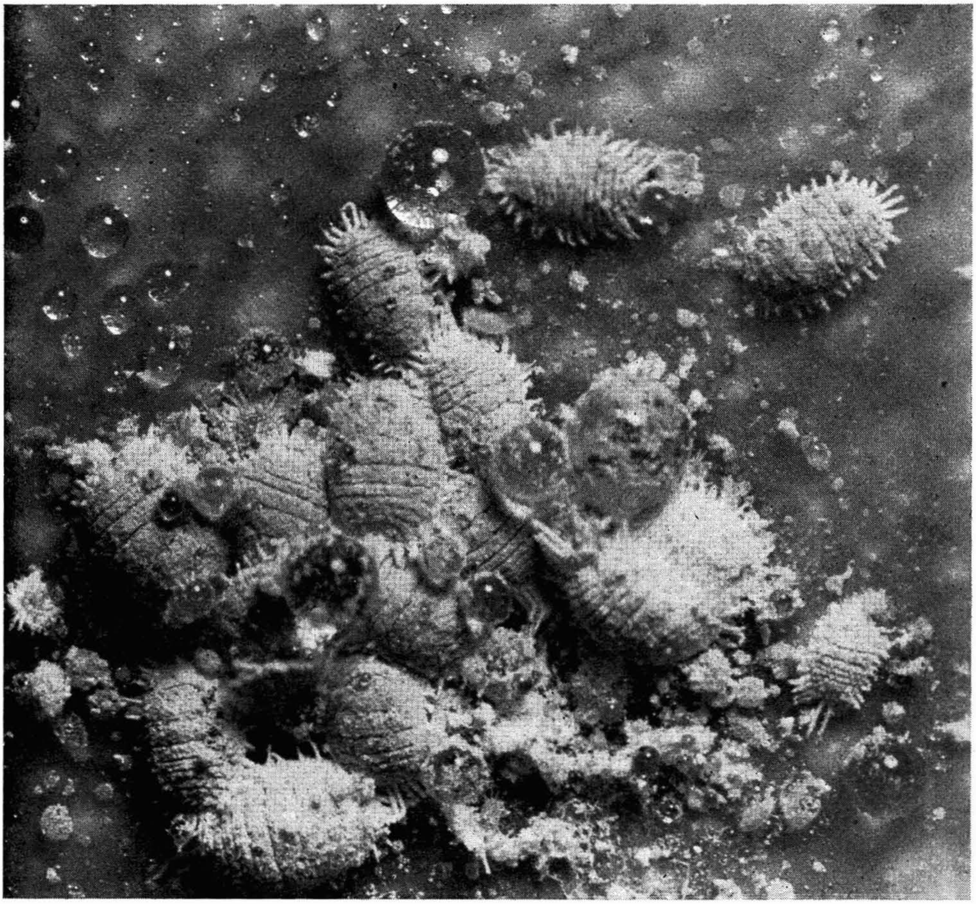


Figure 116—*Pseudococcus citri* (Risso). A colony on a mango fruit and showing glistening globules of honeydew.

Walter Carter tells me that our material has the same mycetome symbiont picture as the European *citri*.

The closing paragraphs on this species and *kraunhiae* are by Ferris.

This is one of a group of closely similar species, the separation of which is extremely difficult and doubtful, and it is possible that as at present understood *citri* is actually a complex of biologically different forms. On the basis of present knowledge the species as here understood may be recognized by the following characteristics:

With 18 pairs of cerarii, which is one more than is commonly found in species of *Pseudococcus,* the additional cerarius apparently being interpolated near the eye. All cerarii with but two rather slender conical setae, with no accessory setae and with but a very slight concentration of pores. No sclerotization present about any cerarii. Ventral side of anal lobes with a small, but very sharply defined, narrow, sclerotized bar extending in from base of anal lobe seta. Dorsum of body

Figure 117—Mango fruits showing damage done by the feeding of colonies of *Pseudococcus citri* (Risso). A new colony is on the left fruit, some necrosis is visible in the midst of the colony on the middle fruit, and a large black area has been exposed by removing an old colony from the mango at the right.

entirely without tubular ducts except as follows: Normally there is a single moderately large duct, which usually possesses an oral rim and is placed slightly in from penultimate cerarius and just behind dorsal ostiole. This duct occasionally lacking, but is the most constant of any of the ducts on dorsum. Ordinarily no duct is present on the segment which bears the ostiole, but occasionally one may be present on the two or even three preceding segments, there thus being a maximum of four such ducts on dorsum and a minimum of none. The only other tubular ducts present on body are smaller, lack an oral rim and are arranged in clusters along posterior margins and near lateral margins of segments on venter of abdomen. Multilocular disc pores present on venter, for most part posterior to circulus, with occasional pores on venter of thoracic segments. Dorsal body setae variable in size, sometimes very few and small but in some specimens larger, slightly swollen toward base.

Over a hundred specimens, from many parts of the world and from many hosts, have been examined in connection with this study. While no assurance is felt that these all belong to a single species, they adhere closely enough to a common pattern to be separable as a group from others of the same general type. The pattern of dorsal ducts is sufficient to separate *citri* from *kraunhiae,* the only other species with which we are concerned here. Hawaiian material at hand, which has in the past been identified as *kraunhiae,* is referable definitely to *citri.*

The identity of *Pseudococcus kraunhiae* (Kuwana) has been a problem for many years, but in connection with work on the *Atlas of the Scale Insects of North America* it has been possible to establish its validity. The species is, in its general features, almost identical with *Pseudococcus citri,* being undoubtedly

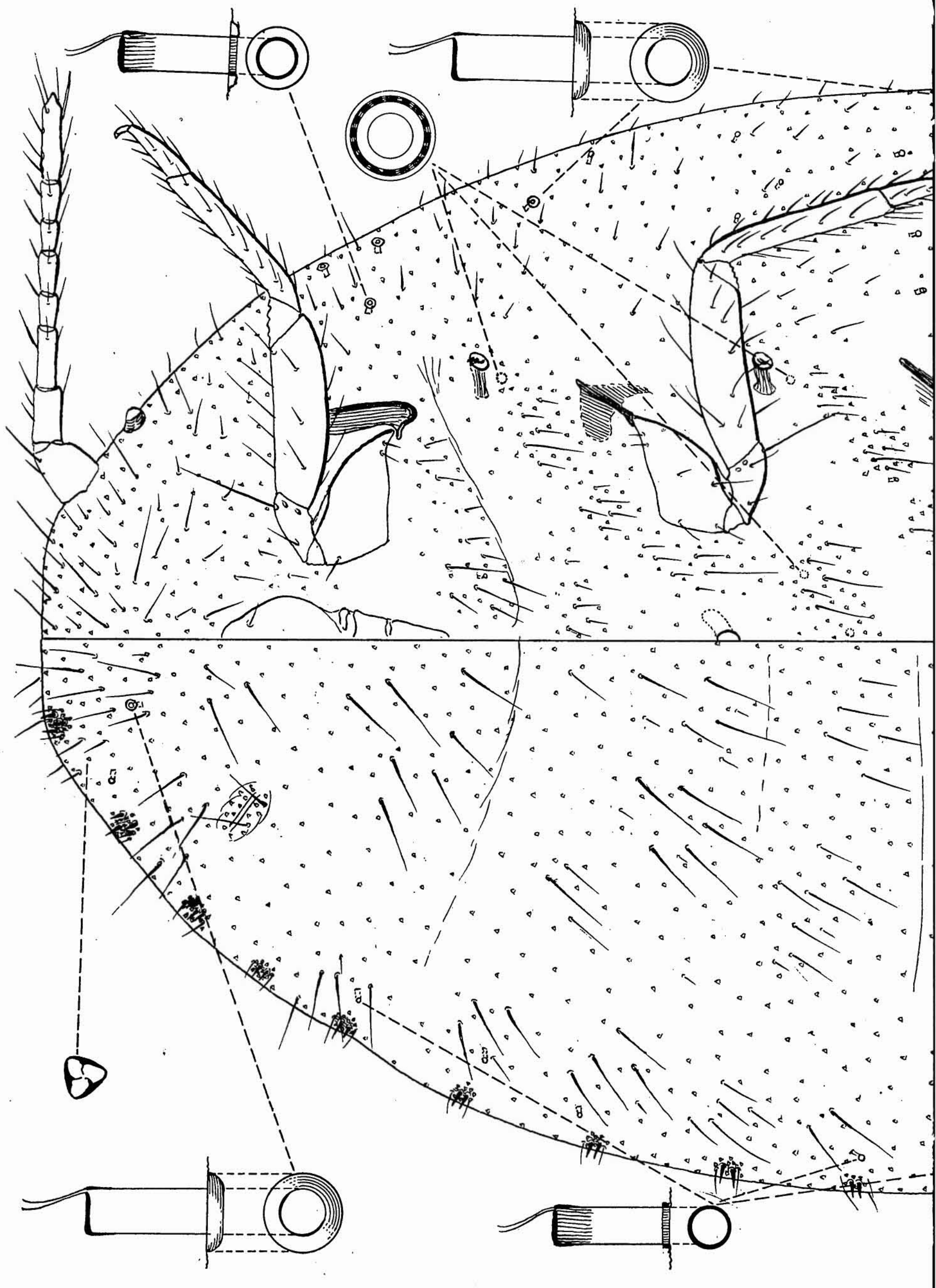
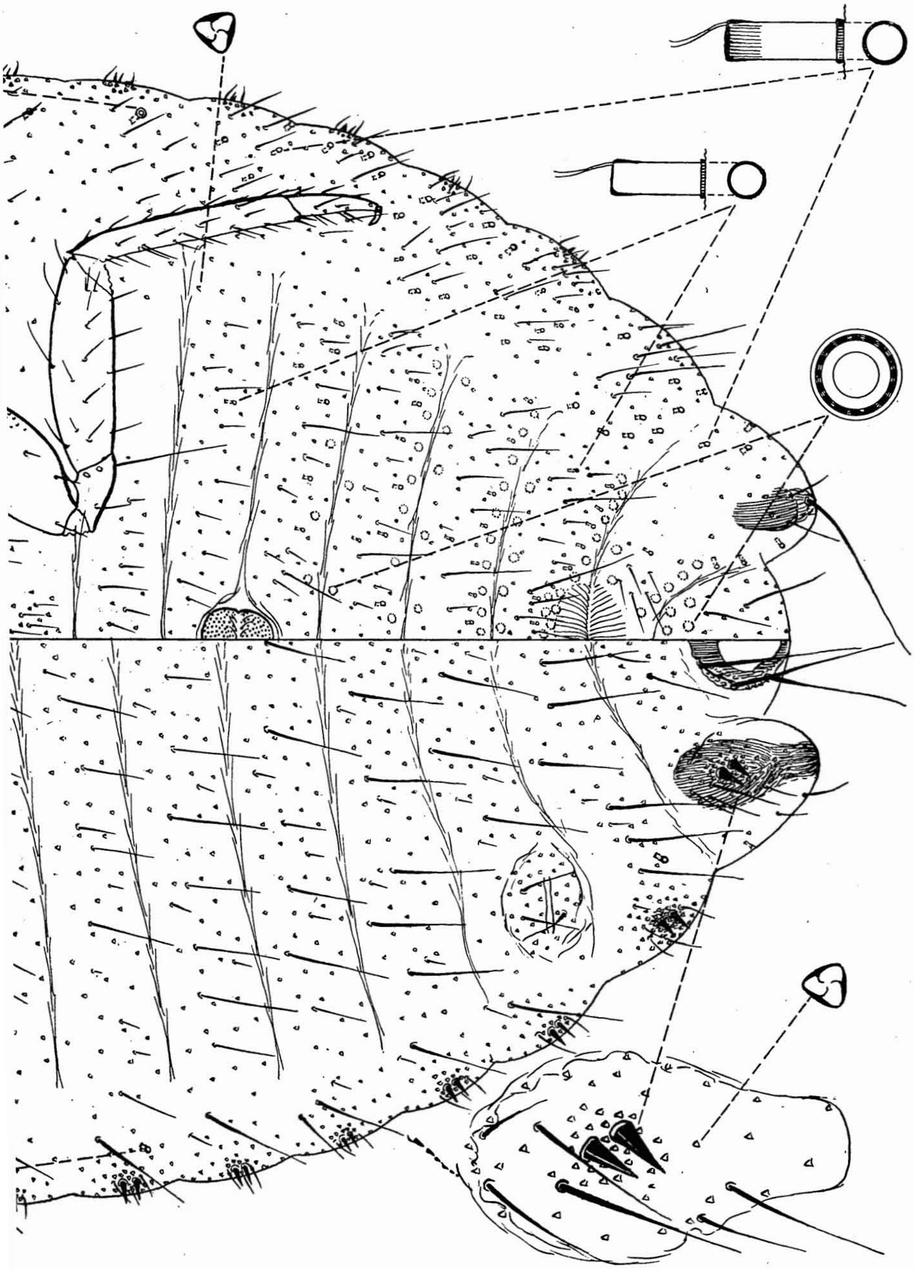


Figure 117½—*Pseudococcus citriculus* Green. (Drawn by Ferris.)



of the same group, the members of which are marked by the presence of 18 pairs of cerarii, all of which, except those on the head, contain but two setae, and the presence of a very sharply defined, little, sclerotized bar which extends in from the base of the anal lobe seta on the ventral side of the anal lobe. In the types of *kraunhiae,* the dorsal setae of the body are very numerous, quite large, slightly swollen toward the base and have a flagellate tip, and this feature shows also in the only other specimens at hand which definitely belong to this species. Unfortunately, however, some specimens of *citri* show enough of this characteristic to make separation of the two on this basis impossible.

The distinctive characteristic of *kraunhiae* is to be found in the presence of quite numerous, moderately large tubular ducts each with a slight oral collar but no oral rim on the dorsum of the abdomen, there being from two to four of these ducts associated with most of the abdominal cerarii. In *citri* there is never more than a single duct (this usually with an oral rim) associated with any of the abdominal cerarii and these ducts are frequently lacking.

The types of this species are at hand, as are a few specimens from *Wistaria* in the Ojai Valley in California. These seem definitely to belong to the same species. Specimens identified as *kraunhiae* are at hand from Hawaii, but they are *citri.*

An illustration of *kraunhiae* (fig. 115) is included here for comparative purposes and to illustrate the characters mentioned by Ferris above.

Pseudococcus citriculus Green (figs. 117½, 118, 119).

Pseudococcus citriculus Green, 1922:377, pl. 254.

Oahu.

Immigrant. A widespread species described from Ceylon. First recorded from the Hawaiian Islands in 1931 by Ehrhorn from specimens collected by him at Honolulu in 1929.

Hostplants: lime, pomelo.

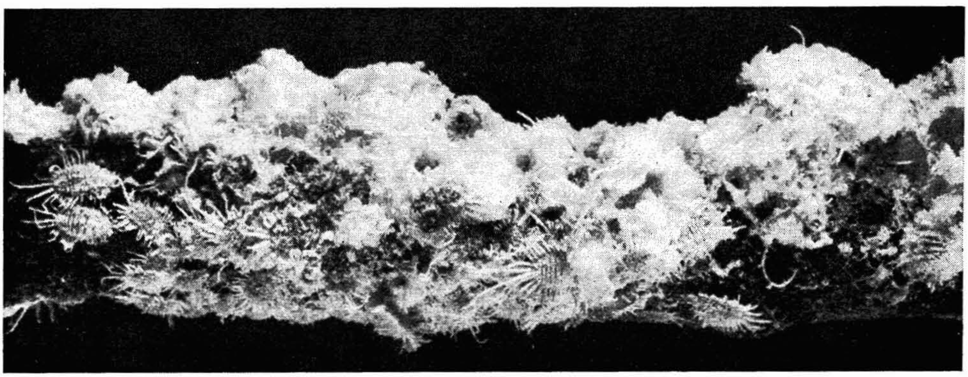


Figure 118—*Pseudococcus citriculus* Green, on a pomelo twig.

Parasite: I have reared a small wasp from the species, but I have not had it identified.

Predator: *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae).

Nothing has been written about the bionomics of this species in our islands, and to my knowledge it has not been noted by anyone since Ehrhorn's first record (*Proc. Hawaiian Ent. Soc.* 8(1):2, 1932), but I have had some infestations under observation recently. Dr. Morrison has examined the original Ehrhorn material for me and agrees that the species is *citriculus* as currently understood. Dr. Morrison has also examined my recent collections and has confirmed the identification.

This species was rediscovered infesting pomelo and lime in Manoa Valley, Honolulu, on the eve of going to press. It produces masses of fluffy, cotton-like wax which may largely conceal the dense colonies which are found mostly on the stems (fig. 118). When colonies occur on the leaves, they tend to concentrate along the midribs of the undersides. The adult females are pale yellow or slightly greenish-yellow in body color. The body fluids, when the insect is crushed, are pale greenish-yellow. The eggs are pale lemon-yellow. There are 17 prominent wax filaments on each side of the body. The frontal ones are about 0.25 to 0.50 mm. long, and the lateral pairs become more or less progressively longer caudad so that the last four or five usually are longer than the breadth of the body, and the caudal pair may be 1.5 mm. long or longer.

If this species should become of economic importance, the Japanese parasite, *Clausenia purpurea* Ishii, might be introduced to aid in its control, according to a note received from Professor Harry Smith. I have found *Cryptolaemus montrouzieri* Mulsant to be a good predator.

Professor Ferris has examined some of the material collected recently, and he has supplied the following notes:

Hosts and distribution: Described by Green from *Citrus aurantia* from the Royal Botanic Gardens in Ceylon. Specimens at hand, determined by Dr. Harold Mor-

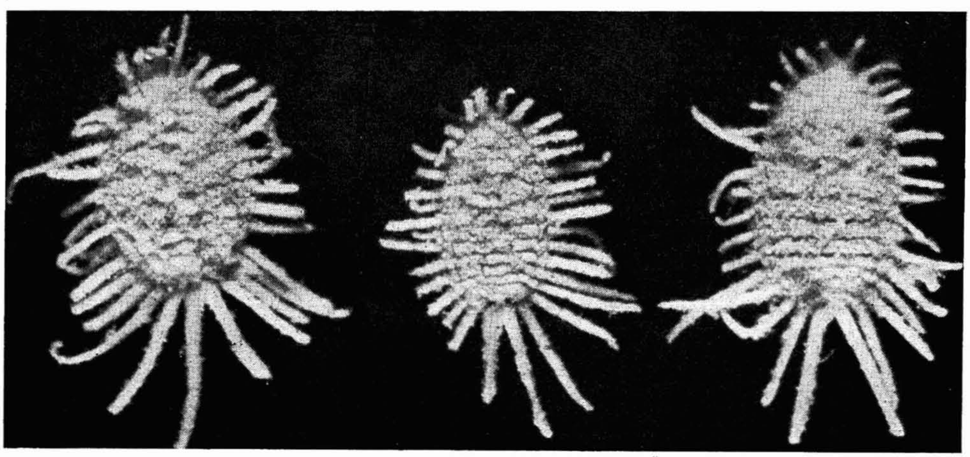


Figure 119—*Pseudococcus citriculus* Green.

rison, are from "pomelo," *Citrus grandis,* Manoa, Honolulu, October 7, 1947, E. C. Zimmerman, collector, and these have been used in the preparation of the illustrations.

Recognition characters: Length of specimens at hand, about 2 mm. A typical *Pseudococcus,* having 17 pairs of well-developed cerarii. Anal lobe cerarii with two quite stout, conical setae, these surrounded by a moderately crowded group of trilocular pores and accompanied by several slender setae of varying lengths, the whole borne in a somewhat elongate-oval sclerotized area. Remaining cerarii each with two somewhat smaller conical setae, except those of the cephalic region which may have three to four setae accompanied by a very definite cluster of pores and three to four slender, auxiliary setae, and at times with a slight sclerotization about the bases of the conical setae. Dorsum rather sparsely beset with trilocular pores and with very few tubular ducts. These ducts are confined to a submarginal row, there being one duct near the cerarius of abdominal segment 8, one near the cerarius of segments 2 to 3 and near each of the metathoracic and mesothoracic cerarii, one near the last prothoracic cerarius and one near the ocular cerarius, this arrangement probably subject to some variation. These ducts are all about as large in diameter as a trilocular pore and have a quite pronounced oral collar. A single oral rim duct of somewhat large size occurs on each side just posterior to the frontal cerarius. Dorsal body setae quite numerous, of various lengths, but most of them strikingly long and slender.

Ventral side of body with a quite well-developed sclerotization on each anal lobe. Multilocular pores present in the midregion of the abdomen on segments 10 to 5, in rather small numbers, there being scarcely more than ten on segment 5 and about 25 to 30 in the posterior row on segment 8. An occasional multilocular pore occurs in the thoracic region. Midregion of the abdomen with a few small tubular ducts, the lateral areas of segments 9 to 4 with several tubular ducts of the oral rim type and of the same size as those of the dorsum. Abdominal segment 4 with a single, large, oral rim duct near the lateral margin on each side, and such a duct is present laterad of the mesothoracic spine. In the lateral areas of the thoracic segments are a few of the oral collar ducts and on the prothoracic segment certain of these ducts develop an oral rim. Venter generally with trilocular pores.

Circulus present. Antennae eight-segmented, quite slender. Legs presenting nothing distinctive.

Notes: The especially distinctive features of the species are the unusually long and slender dorsal setae combined with the sclerotized area about each anal lobe cerarius.

Pseudococcus floriger Ferris, new species (fig. 120).

Host and distribution: From *Dracaena aurea,* at Kanaio, Maui, T. H., at an altitude of 2,600 feet, April 30, 1945, E. C. Zimmerman, collector.

Habit: Numerous at the bases of the leaves of the host.

Recognition characters: Length (on slide) about 2 mm. Antennae eight-segmented. Circulus lacking. Legs moderately short, but not distinctively so. Cerarii much reduced in numbers. Some specimens show the frontal cerarius, but in others this is lacking, and in most of available material there are but six or seven recognizable pairs, these being along abdomen. Anal lobe cerarius with two conical setae and several slender setae, these borne in a rather small, but sharply defined, sclerotized area, the area beset with numerous pores which are only slightly concentrated about conical setae. Penultimate cerarius with two conical setae, four or five slender setae, a cluster of pores and a slight, but not definitely defined surrounding sclerotization. Remaining cerarii similar but with conical setae smaller, with at most but one or two slender setae and with few pores.

Marginal areas, both dorsally and ventrally, from anal lobes to head, with rather numerous tubular ducts, these moderately large and with an oral collar, an occasional duct showing an oral rim. Trilocular pores rather sparse. Dorsal setae sparse, of various sizes, but all slender. On ventral side of body there is a very small, sclerotized area at base of each anal lobe seta. Vulva in many specimens showing a peculiar, slightly sclerotized internal folding which has suggested the specific name. This disappears or becomes obscured in old females after the eggs have been deposited. Multilocular disc pores very few, confined to area immediately about vulva. In addition to larger submarginal ducts there are a few very small tubular ducts in midregion anterior to vulva. Setae sparse, all slender and rather small. Trilocular pores sparse.

Notes: The internal folding about the vulva is indicated in some other species, but seems to be unusually well developed in this species. Otherwise, the nature of the anal lobe cerarii, the absence of the circulus and the groups of submarginal tubular ducts are distinctive of the species. A considerable number of specimens has been available.

This is an endemic species. The holotype slide is in the Bishop Museum.

Pseudococcus gallicola Ehrhorn (fig. 121).
Pseudococcus gallicola Ehrhorn, 1916:241.

Endemic. Oahu (type locality: in the original description only specimens from Palolo Valley, Honolulu, are mentioned, but there has been an omission; the female holotype slide is made from the specimens from *Santalum littorale* which were collected at Makua, Oahu, February 20, 1910, by Swezey; the cotype females are from Palolo Valley), Maui.

Hostplants: *Santalum ellipticum* (?), *S. freycinetianum* (?), *S. littorale, S. haleakalae.*

Parasite: *Anagyrus nigricornis* Timberlake (Hymenoptera: Encyrtidae).

The galls, or rather pockets, in which the insect lives are usually on the upper side of the leaves. The young larvae station themselves on the underside of the very young, tender leaves, and by irritation cause a depression in the leaf, which grows very quickly, forming a deep, pocket-like gall. As the insect grows its caudal filaments protrude from the opening of the gall. Some galls are found on the underside of the leaves, but not very often. (Ehrhorn, 1916:241–242.)

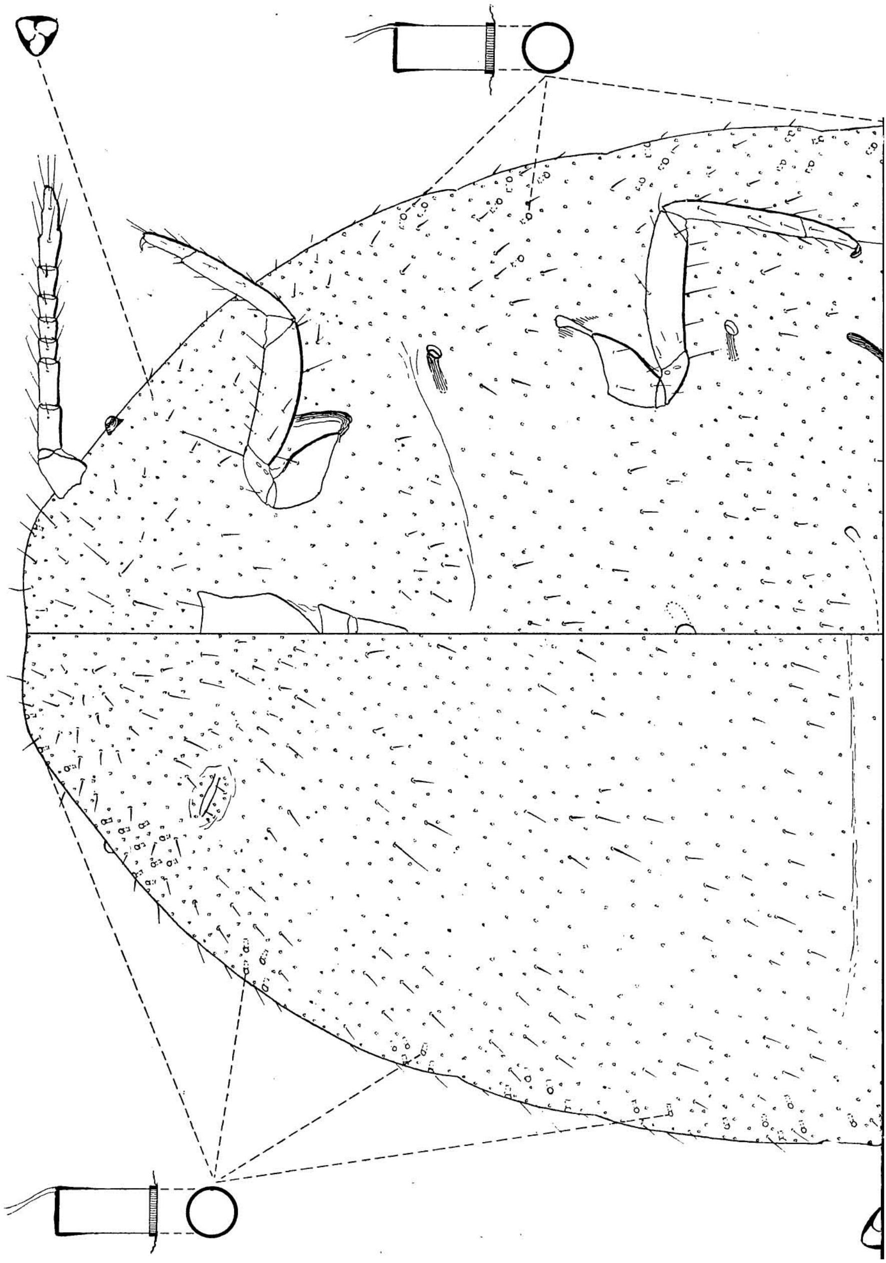
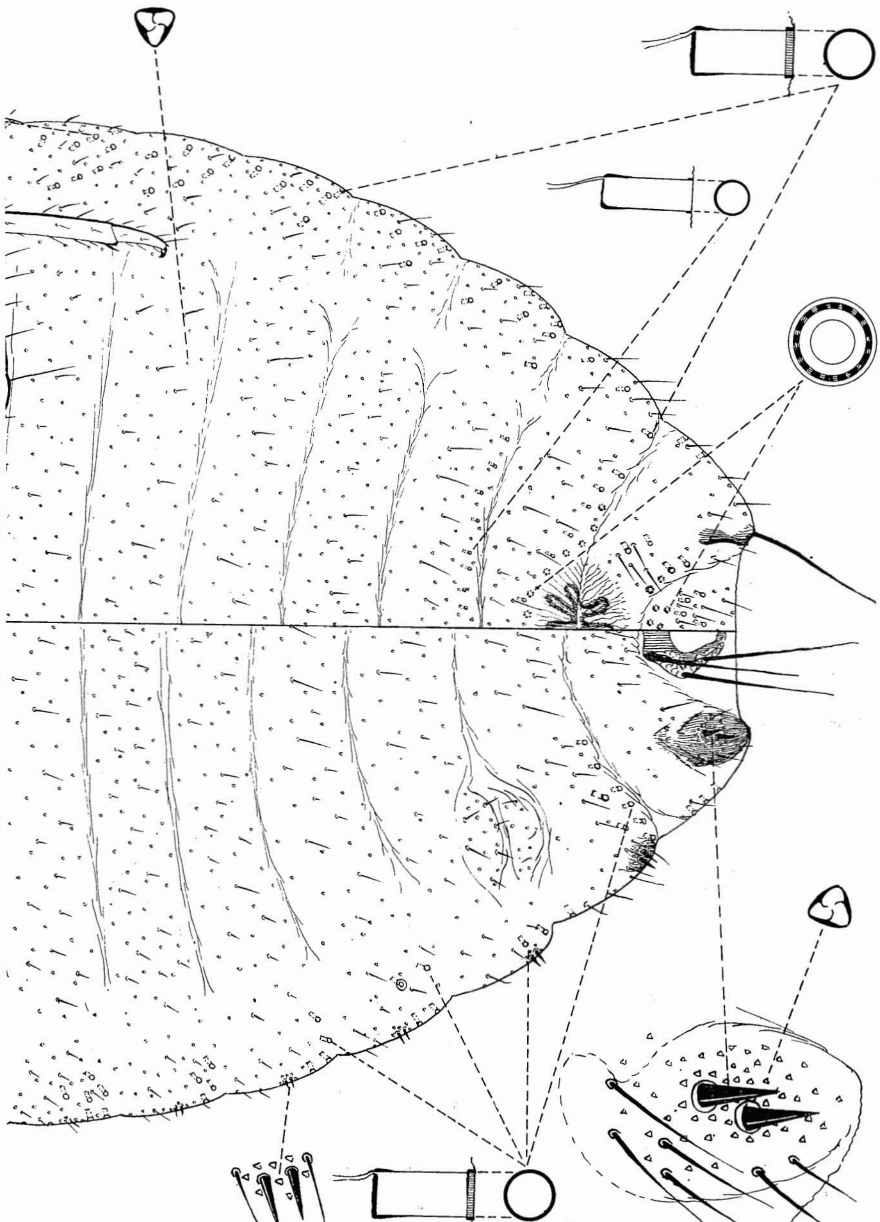


Figure 120—*Pseudococcus floriger* Ferris, new species. (Drawn by Ferris.)



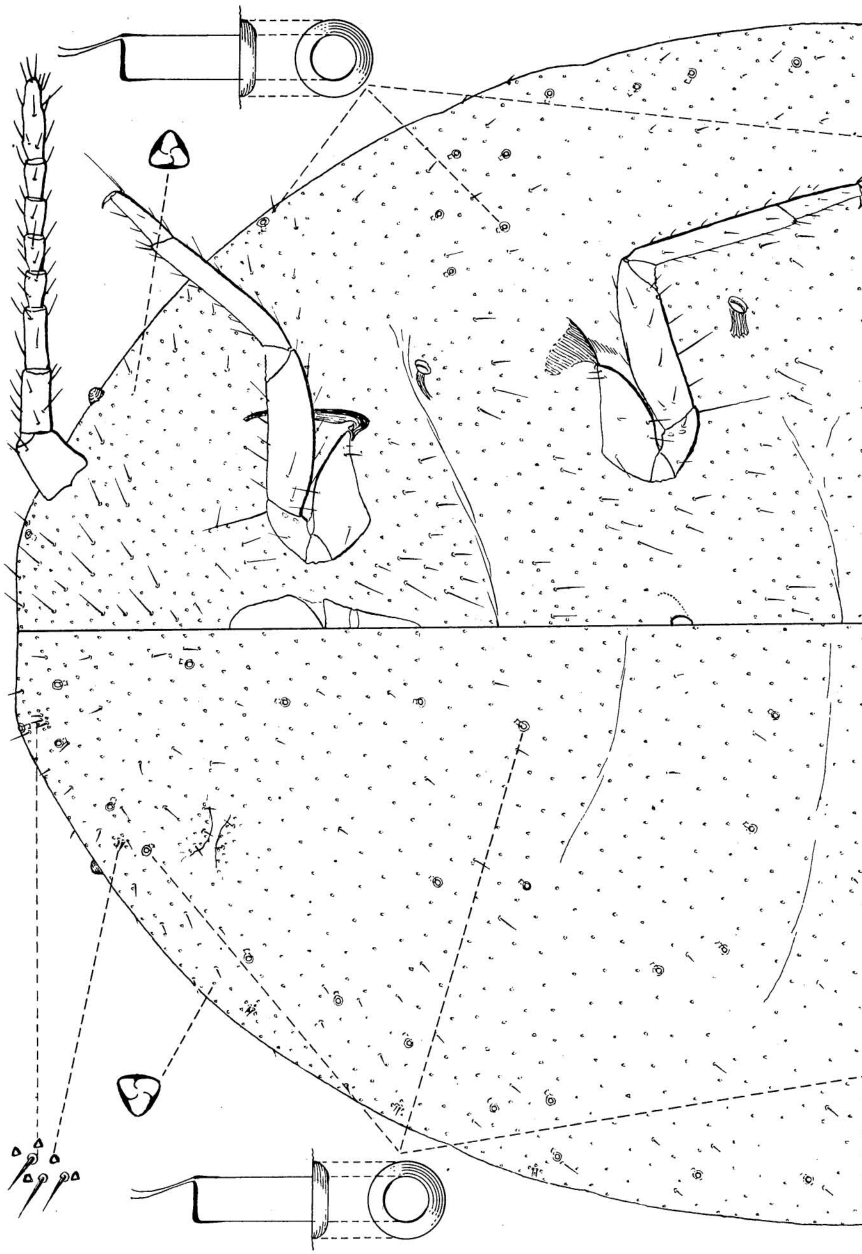
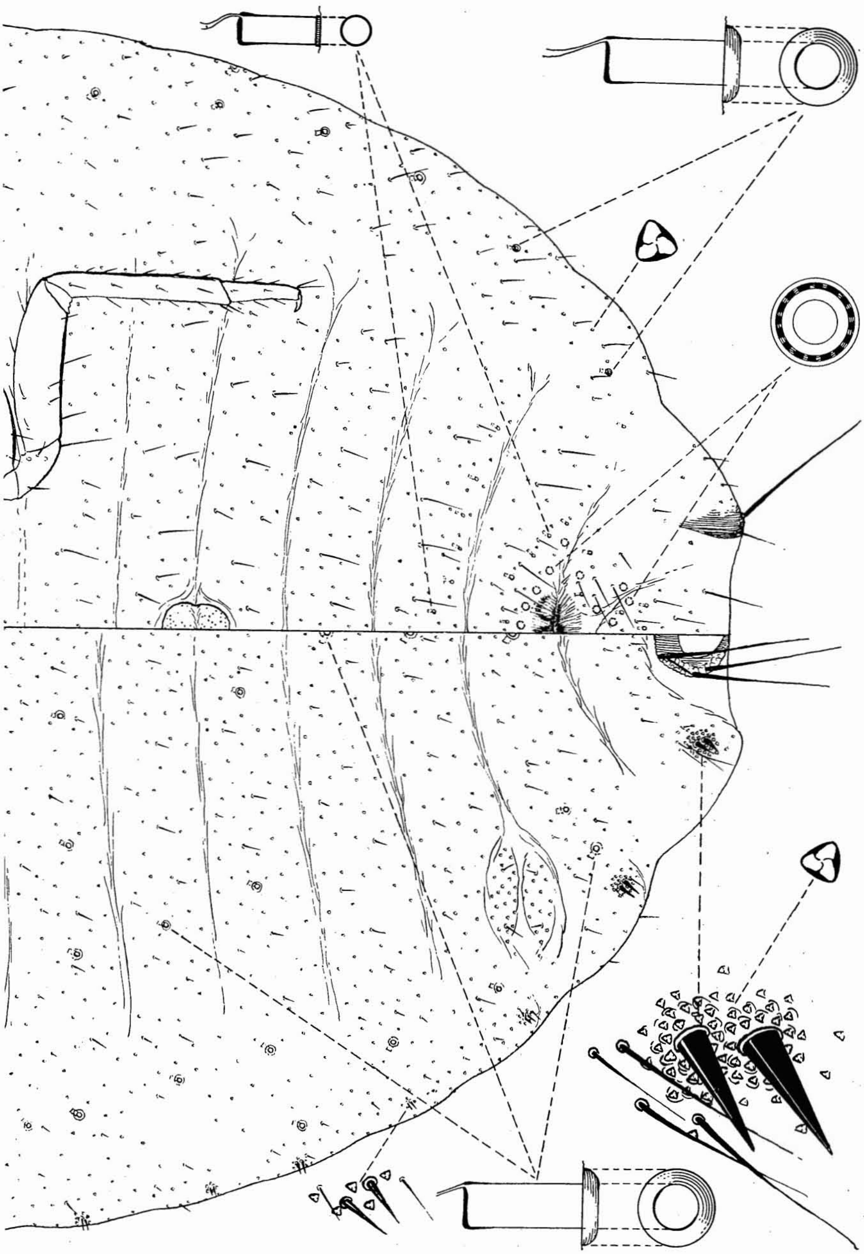


Figure 121—*Pseudococcus gallicola* Ehrhorn. (Drawn by Ferris.)



Ehrhorn (1916:241) described the adult females, which are ovoviviparous, as follows: "convex, varying from a grayish green to a yellowish brown color, with a faint dark line running lengthwise in the center of the dorsum. There are three pairs of filaments, which are quite pronounced, the two caudal ones being about twice as long as the two preceding pairs. The filaments on the four other segments are very short. . . ."

Ehrhorn himself confused more than one species under this name. Slides in the Ehrhorn collection bearing this name, but from *Eugenia sandwicensis*, represent another species. It may be that his type series was mixed. I have been unable to obtain fresh material from *Santalum littorale*.

The Maui record is based upon my collection from *Santalum haleakalae* growing at 7,500 feet on the road to the summit of the crater. The galls from this collection were open, dome-shaped invaginations, usually on the upper leaf surface (that is, the young mealybugs attack on the lower leaf surface, causing the leaf to bulge upward at the point of attack, thus making a hollow on the lower surface and a gall protuberance on the upper surface). These galls are very different from those of *Pseudococcus antricolens*.

It would appear logical to call this species *gallicolus*, but the proper form is *gallicola*, for *cola* is of common gender.

The following details are by Ferris:

Recognition characters: Length (on slide) about 3 mm. Circulus present. Antennae normally eight-segmented and rather long. Legs presenting no distinctive features. Cerarii somewhat reduced in number and this number variable as between opposite sides of same specimen, and among four type specimens at hand, more so if all available specimens are considered. Maximum number observed on one side of body is 12, with total reduced to as few as seven or eight in some instances, the tendency being for the cerarii to disappear along thoracic area. Anal lobe cerarii with two stout, conical setae and three or four slender setae, conical setae surrounded by a cluster of closely set pores which are arranged concentrically and symmetrically about setae. There appears to be a diffuse and rather weak and indefinitely defined sclerotization about these cerarii. Penultimate cerarius with conical setae small and accompanied by three or four slender setae and a cluster of pores, but without sclerotization. Anterior to this the conical setae tend to become progressively smaller, slender setae may be lacking and even pores may be lacking. Frontal and ocular cerarii are present normally and contain two or three very small, conical setae and a few pores, although they may at times be lacking. Moderately large tubular ducts with an oral rim are distributed over the dorsum, there being usually one near each cerarius or site of a cerarius and others scattered about as indicated in illustration. Trilocular pores of normal abundance. Dorsal setae rather sparse, of various sizes but all small. Ventral side of anal lobes with a small, sclerotized area at base of anal lobe seta, this scarcely indicated in unstained types. Multilocular disc pores extremely few, there being a total of scarcely more than 20 and these confined to postvulvar and first prevulvar segments. Oral rim ducts, like those of dorsum, present in small numbers in lateral thoracic areas and there is normally one near each abdominal cerarius. A very few,

extremely small, tubular ducts with an oral collar present in region of vulva and along posterior margin of two prevulvar segments. Trilocular pores sparse. Setae sparse, all quite small and slender.

Notes: The type slide contains four individuals. The preparations are poor, but by combining what can be learned from each and by cautious utilization of the two additional mounted specimens collected from Maui in 1945, it is possible to present an illustration of the species. The 1945 specimens agree definitely with the types. The absence of any very definite sclerotization about the anal lobe cerarii, and the normally slender, eight-segmented antennae seem to distinguish this species from that most nearly like it, which is herein described as *Pseudococcus antricolens*.

Pseudococcus giffardi (Ehrhorn) (figs. 122, 123).
Tylococcus giffardi Ehrhorn, 1916:243.

The pandanus mealybug.

Oahu (type locality: Honolulu).

Immigrant. Source undetermined, but probably a western Pacific species.

Hostplants: *Freycinetia, Pandanus odoratissimus* ("hala") (principal host).

Predators: *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae); *Gitona perspicax* (Knab) (Diptera: Drosophilidae).

This is a common species on *Pandanus*. Although densely clothed with white mealy wax, the body segmentation is distinct on the adult females. The wax filaments (17 on each side) are coarse and heavy, the lateral ones may be as long as the breadth of the body, and the caudal ones may attain a length of between 2 and 3 mm. These filaments vary in length because of breakage. The body of the adult females is yellowish with a somewhat pinkish cast; no ovisac is formed, for they are ovoviviparous, and the young cluster beneath the mother. They feed on the leaves, especially near the bases, where colonies frequently are found. The leaves become dusted with white wax in the parts infested with mealybugs. They do not resemble *Orthezia,* as stated by Ehrhorn.

The following data are supplied by Ferris:

While it is entirely possible that this species does not actually belong to the genus *Pseudococcus,* it is perhaps best to refer it to this genus until, and unless, a comprehensive study of the group for the world indicates a different arrangement. No one knows what the genus *Tylococcus,* in which it was originally placed by Ehrhorn, actually is.

The species is readily recognizable. Each of the 17 pairs of cerarii has 10 or more conical setae of various sizes and each cerarius is borne upon a sclerotized area, the area on the anal lobes being the largest, the others becoming progressively smaller toward the anterior segments of the abdomen and from there forward remaining about the same size. Circulus lacking. Multilocular disc pores confined to ventral side of body, occurring for the most part on last six abdominal segments, but a few present even to prothorax. Tubular ducts of but a single

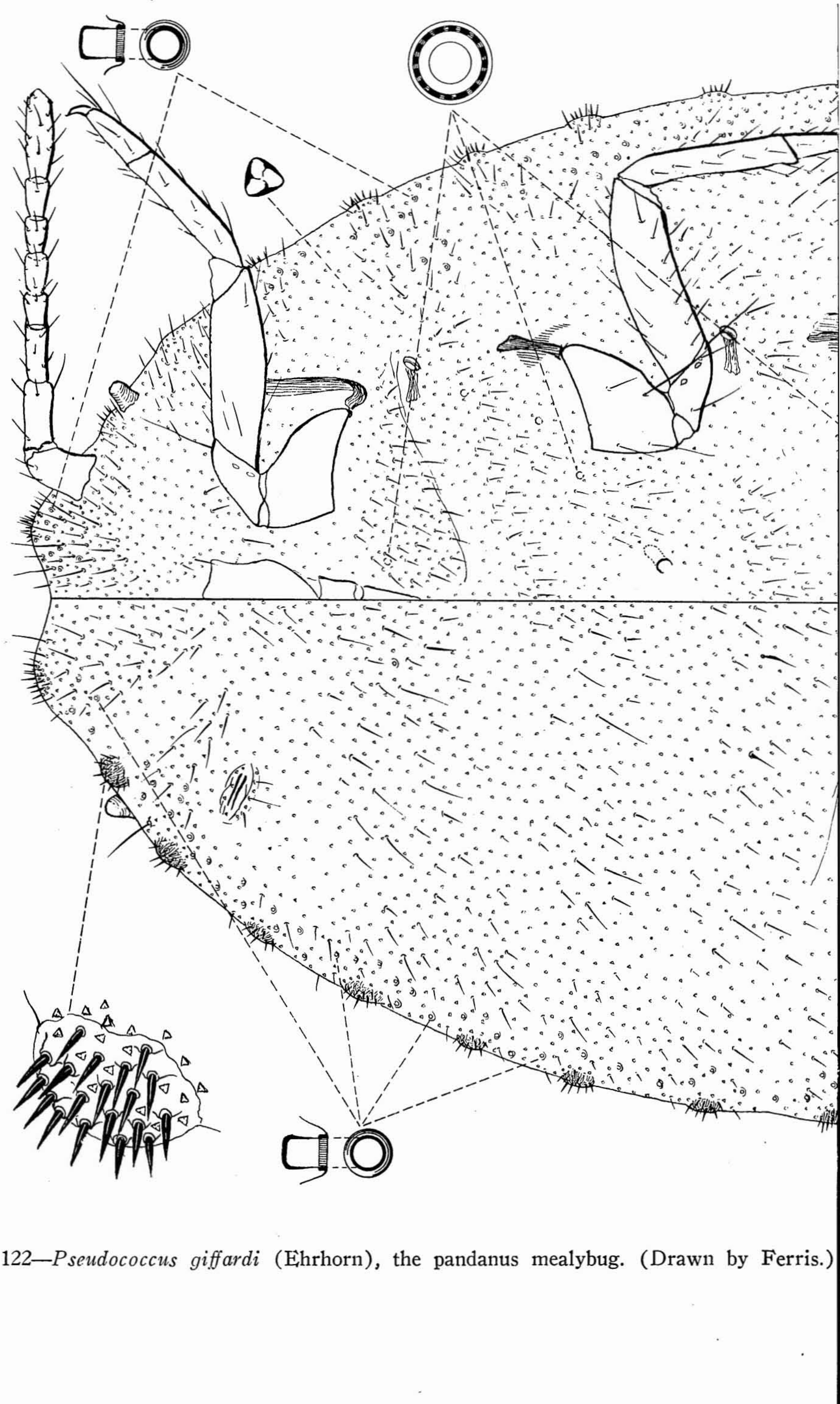
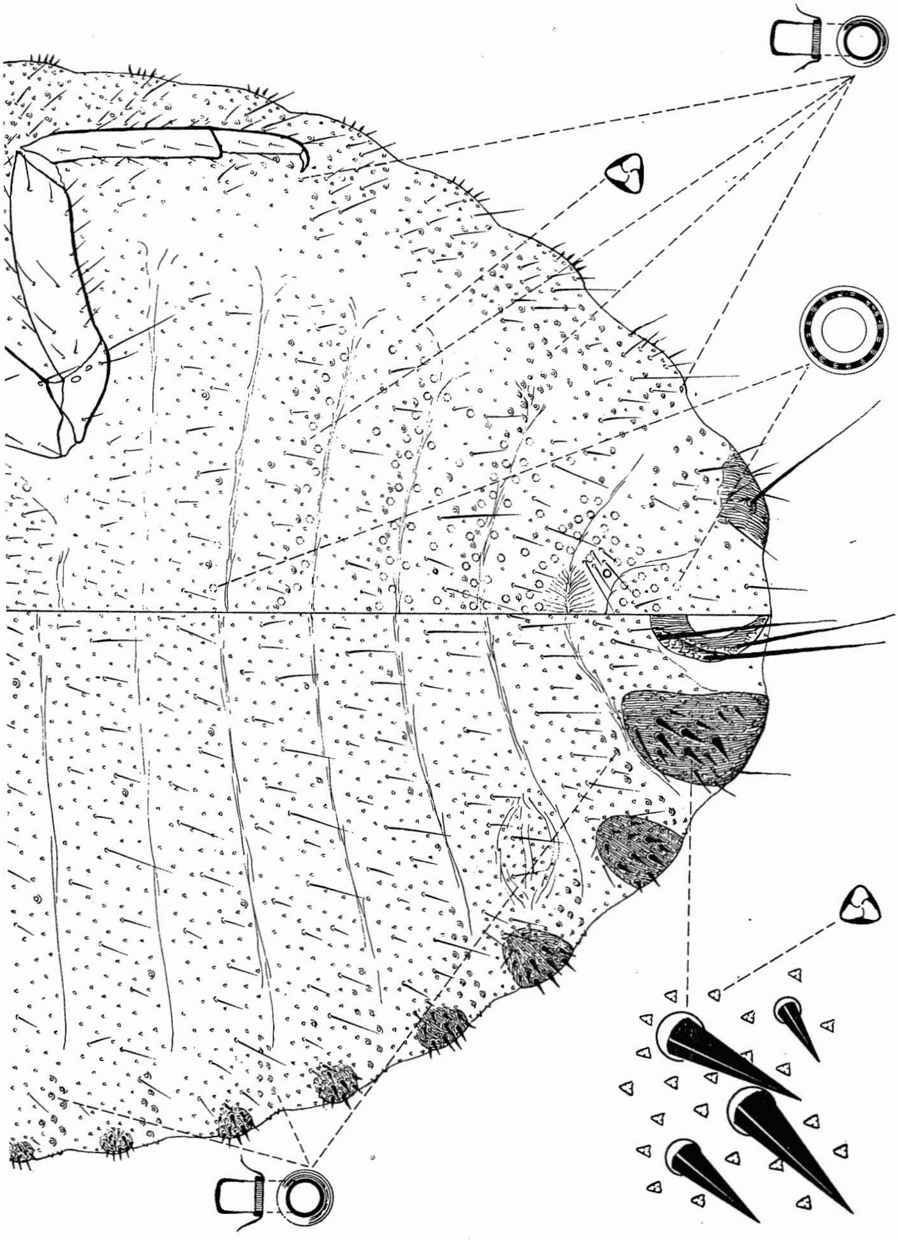


Figure 122—*Pseudococcus giffardi* (Ehrhorn), the pandanus mealybug. (Drawn by Ferris.)



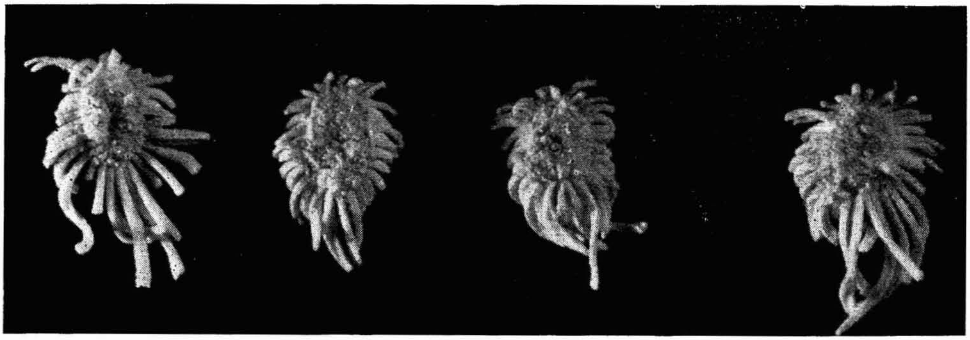


Figure 123—*Pseudococcus giffardi* (Ehrhorn), the pandanus mealybug.

type present, these occurring in large numbers and for the most part along lateral regions of body, all very small and short, being scarcely longer than broad, each with short, thick collar and with orifice somewhat elevated, or with an oral rim.

The accompanying figures are from specimens received from E. M. Ehrhorn and indicated as being from the "type tree."

Pseudococcus maritimus (Ehrhorn) (fig. 124).
Dactylopius maritimus Ehrhorn, 1900:316, pl. 7, fig. 7.

The Baker or grape mealybug.

Oahu.

Immigrant. A widespread pest (described from California). Intercepted many times over a long period of years at quarantine at Honolulu, but first found established in the islands by Swezey in 1936 (Suehiro, 1937:429).

Hostplants: *Alpinia purpurata,* eggplant, *Gladiolus,* orchids.

This is a serious pest of various fruits and of other crops elsewhere, and we can expect it to assert itself here in the future, unless controlled by parasites and predators.

The adult females are reddish in body color, the segmentation shows through the dorsal meal, the lateral wax processes are short but there is a longer caudal pair which may be between one-fourth to one-half as long as the body, and the yellow or orange eggs are enclosed in a fluffy ovisac.

Ferris' notes follow:

Morphologically this species—or species complex—is recognizable by the following characters: With 17 pairs of cerarii, all with at most two conical setae, except those in head region which may have three or four, and with several small accessory setae. Anal lobe cerarii with conical setae quite large and stout and surrounded by a concentrated cluster of numerous pores, area occupied by these pores frequently being somewhat depressed. In well-stained specimens there is a faint sclerotization shown laterad of pore area, but this is usually entirely lacking. Anterior to this cerarius the conical setae become smaller and have only a small

cluster of associated pores and accessory setae. Ventral side of anal lobe with a well-defined sclerotized area extending in from base of anal lobe seta, this area variable in shape and size but always present. Tubular ducts of dorsum—except for a marginal cluster between penultimate and anal lobe cerarii—few, all quite large and with a definite oral rim. There is normally one such duct just in from each cerarius and a few somewhat variably arranged over remainder of dorsum. Smaller tubular ducts without an oral rim and with a very slight oral collar are present in considerable numbers on ventral side of abdomen and in marginal regions of body from anal lobes to head. Multilocular disc pores confined to venter, present in moderate numbers on abdominal segments and occasionally to be found on thorax. Circulus present.

Evidence is accumulating that in North America, where this species is presumably native, there are at least two species now identified under this name. Biologically they are clearly different, but at the present time no means of separating them morphologically have been found, although it is to be hoped that eventually this can be done. The accompanying illustrations are based upon specimens from the type host and locality in California.

Pseudococcus mendiculus Ferris, new species (fig. 125).

Host and distribution: From *Myrsine*, Kanaio, Maui, Hawaii, April 30, 1945, E. C. Zimmerman, collector.

Habit: Unknown; beaten from foliage by the collector.

Recognition characters: Adult female (on slide) about 1.5 mm. long. Antennae eight-segmented. Legs noticeably short. Circulus—in the single available specimen—present but extremely small and weakly developed. Cerarii reduced along mid-region of body so that a total of only about 13–14 pairs can be recognized. Anal lobe cerarius with two conical setae, several slender setae, a very small cluster of pores about conical setae and a slight suggestion of surrounding sclerotization. Penultimate cerarius with conical setae smaller, with two or three slender setae and a few pores. Anterior to this the conical setae become still smaller and are accompanied for most part by one or two slender setae and a very few pores, in part becoming so small that they become almost or quite unrecognizable as cerarii. Frontal cerarius with three small conical setae, two or three slender setae and a very few pores. Dorsum entirely without tubular ducts except a single, quite small, oral collar duct placed submarginally opposite posterior coxae. Dorsal setae sparse, of various sizes but all small and slender. Trilocular pores sparse.

On the ventral side of body there may be a slight sclerotized area at base of anal lobe seta, but this cannot be positively determined from available specimen. Multilocular disc pores few, there being scarcely more than a dozen immediately around vulva. Tubular ducts extremely few, of two sizes. Extremely minute ducts appear in area anterior to vulva in such small numbers that they can scarcely be detected. A larger size, similar to those described for dorsum, occurs, there being a submarginal series that includes a single duct near some of abdominal and thoracic

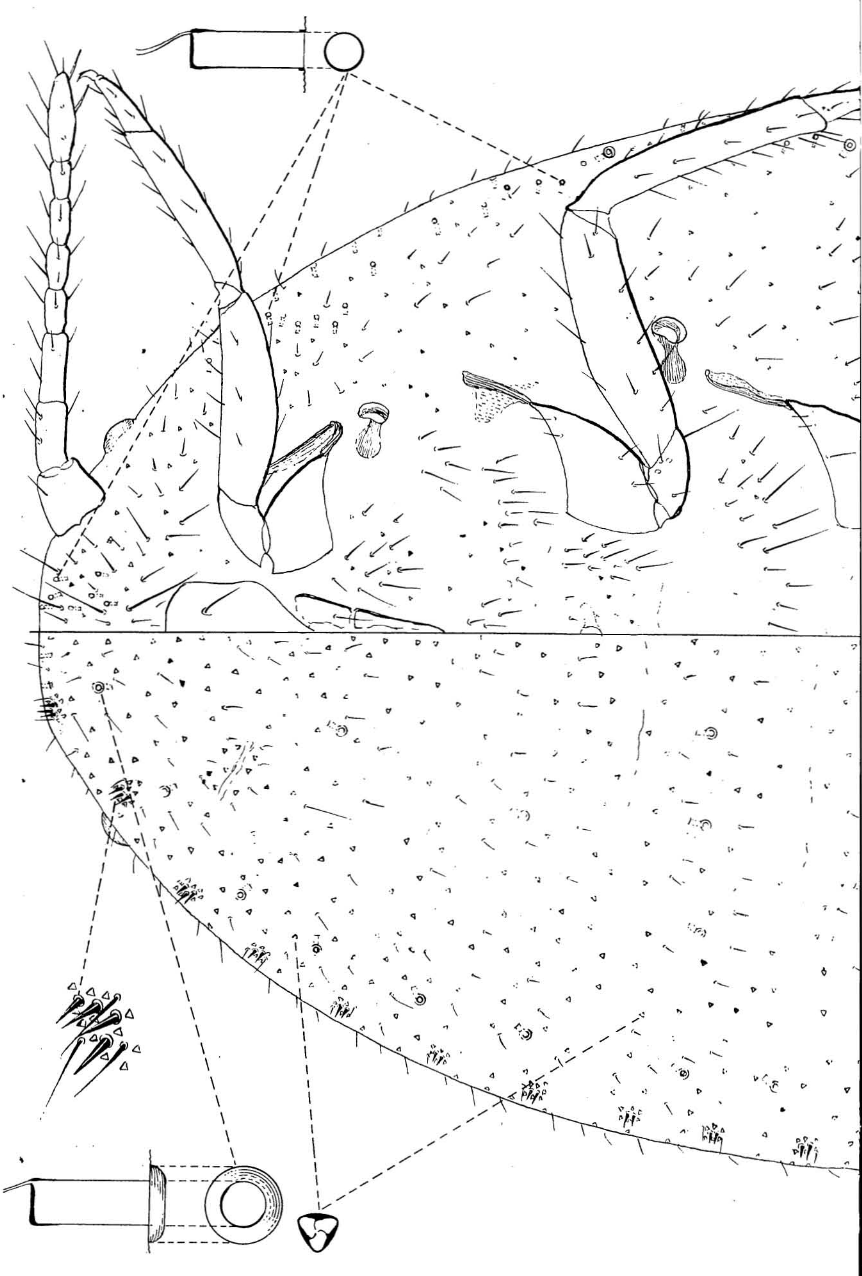
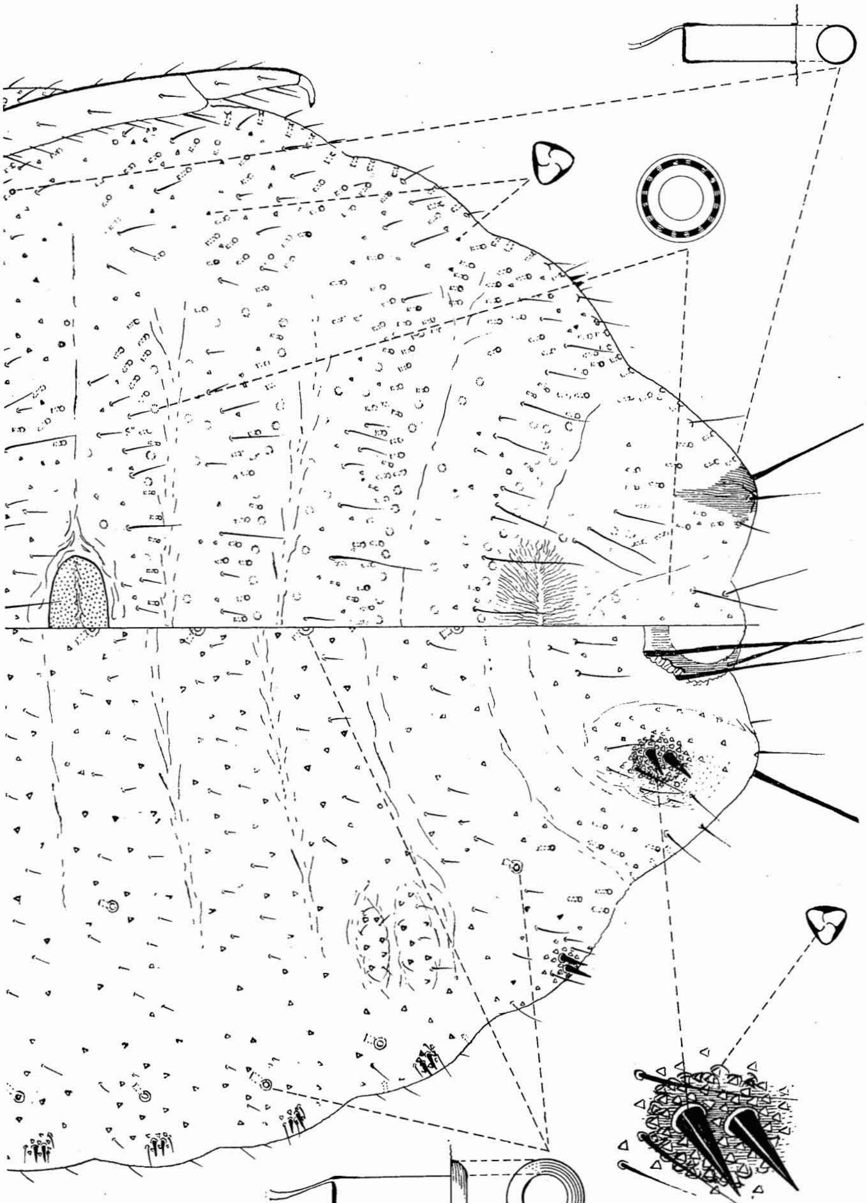


Figure 124—*Pseudococcus maritimus* (Ehrhorn), the grape mealybug. (Drawn by



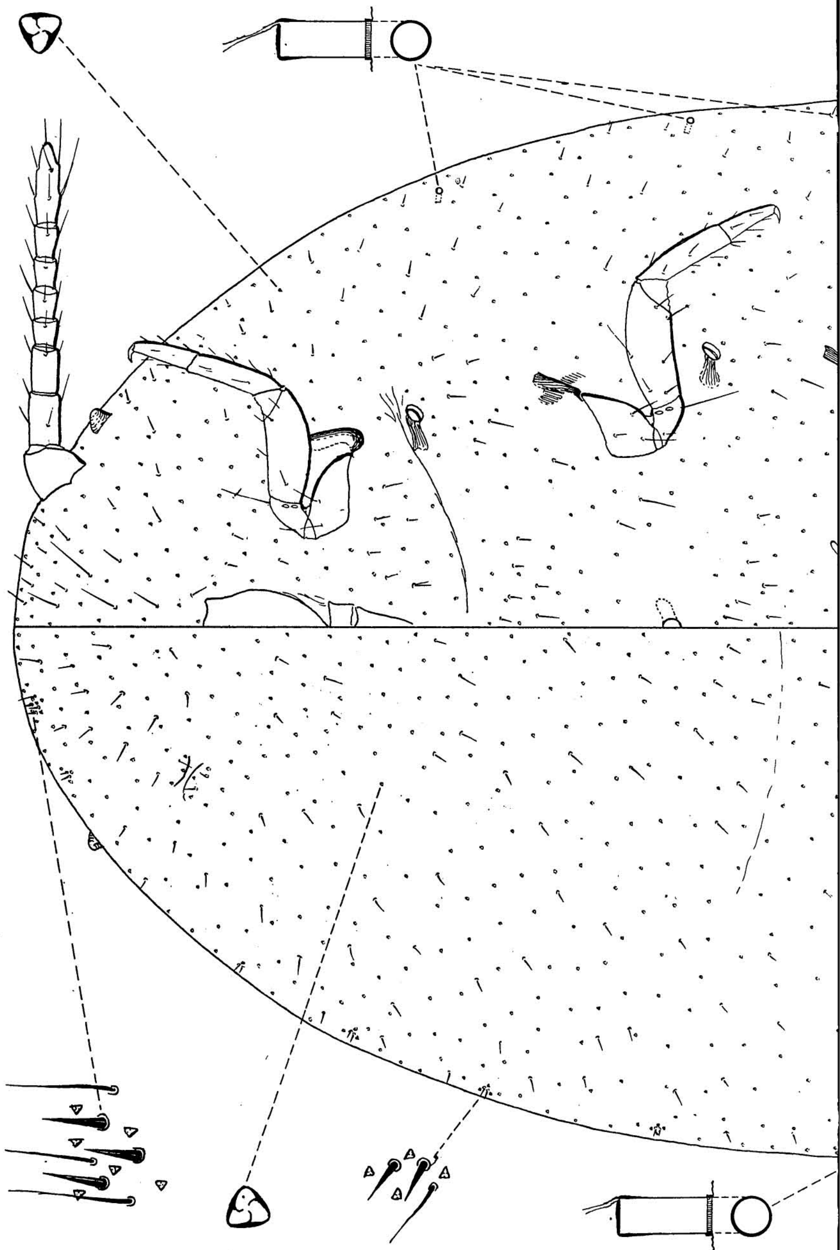
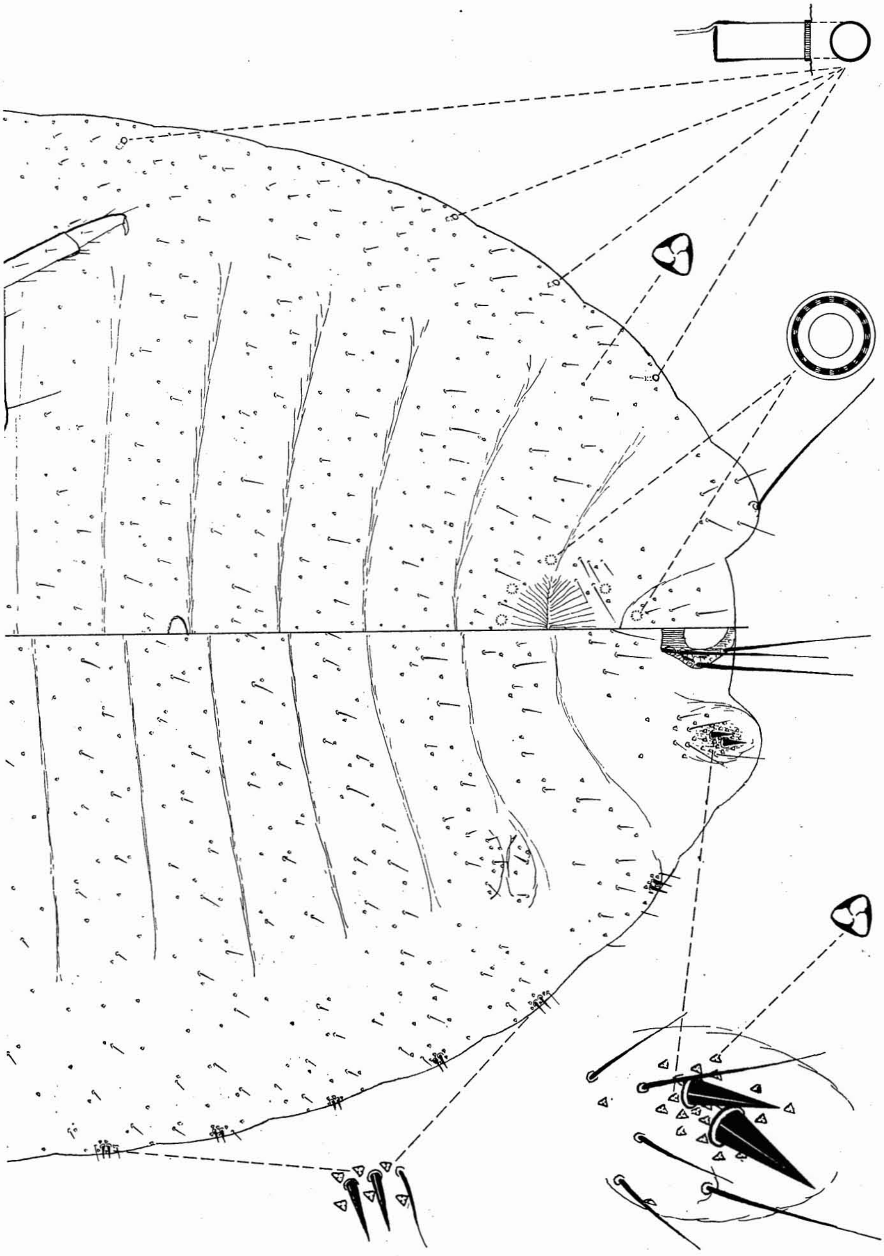


Figure 125—*Pseudococcus mendiculus* Ferris, new species. (Drawn by Ferris.)



cerarii. Trilocular pores sparse. Setae sparse, of various sizes but all small and slender.

Notes: This endemic species is even more featureless than is *P. nudus,* to which it seems to be quite closely related, although, on the basis of available material, it is distinct. The weak sclerotization and the few pores of the anal lobe cerarii and the absence of oral rim ducts seem to be distinctive. The circulus can scarcely be detected in even a well-stained specimen and can easily be overlooked. It probably varies and may prove to be lacking at times.

The holotype slide is in the Bishop Museum.

Pseudococcus montanus Ehrhorn (fig. 126).
Pseudococcus montanus Ehrhorn, 1916:237, 242.

Endemic. Oahu (type locality: Palolo Valley), Maui (?), Hawaii (?).

Hostplants: *Astelia veratroides, Freycinetia* ("ieie").

Parasite: *Anagyrus nigricornis* Timberlake (Hymenoptera: Encyrtidae).

The adult, brownish-yellow females are apparently ovoviviparous, but they produce a fluffy mass of wax. The numerous lateral filaments are mostly short, longer caudad, but the caudal pair may become as long as, or longer than, the body. The dorsum is so thinly clothed with meal that the body color and segmentation are visible. They are often found in abundance between the bases of the leaves of their hostplants. Notes by Ferris follow:

This species is one of a group of several closely related forms, all of which are marked by presence of a sclerotized area surrounding each anal lobe and penultimate cerarii. Some of these species, which unfortunately cannot at present be identified, occur in the southwest Pacific area. From them *montanus* may be differentiated by the following combination of characters:

Anal lobe cerarius surrounded by a large and definitely sclerotized area which bears numerous trilocular pores, these pores being scattered quite uniformly over the area and not especially concentrated about the two stout, conical cerarian setae. Penultimate cerarius surrounded by a much smaller, but quite definite, sclerotized area and with pores distributed in same manner. Anterior to this the cerarian setae become progressively smaller and the surrounding sclerotized area smaller and less well defined until on thorax the cerarian setae are quite small, no sclerotized area appears and the pores form only a small cluster. Dorsum throughout with scattered tubular ducts, and marginal areas ventrad of cerarii with many such ducts which are quite broad and short, each with a well-developed oral collar. The orifices of these ducts may be slightly elevated but they do not have a distinct oral rim. Very small ducts are present in small numbers on venter along posterior border of each of three or four prevulvar segments. Multilocular disc pores relatively few, confined to area about vulva and to posterior borders of two or three segments anterior to vulva. Circulus present but very small.

Pseudococcus perforatus Ferris, which has been reduced to a synonym of this species, is distinct.

The accompanying figure is based upon specimens from *Freycinetia,* Puu Kalena, Oahu, March 22, 1936, collected by Amy Suehiro.

Pseudococcus nipae (Maskell) (figs. 127, 128).
Dactylopius nipae Maskell, 1892:232, pl. 15, figs. 12–15.
Trechocorys nipae (Maskell) Kirkaldy, 1904:154.

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. A widespread species. First called to notice at Honolulu by Perkins in 1902.

Hostplants: *Arecastrum romanzoffiana,* asparagus, avocado, banyan, breadfruit, canna, fig, grape, guava, mulberry, palms, *Pritchardia, Sterculia urens, Straussia, Urera.*

Parasite: *Pseudaphycus utilis* Timberlake (Hymenoptera: Encyrtidae) (purposely introduced from Mexico in 1922).

Predators: *Hyperaspis silvestrii* Weise; *Cryptolaemus montrouzieri* Mulsant; *Lindorus* sp., *Rhizobius ventralis* (Erichson) in literature; *Curinus coeruleus* (Mulsant) (imported especially to control this species) (Coleoptera: Coccinellidae).

The adult ovoviviparous females are yellow or orange in body color, and they have characteristic lumps or tufts of white or yellow wax on the dorsum.

Here again we find a confused state of affairs as to the proper name, or names, to apply to this complex. A number of workers have considered the yellow forms occurring principally on palms to be *Pseudococcus pseudonipae* (Cockerell) (1897: 302), whereas the white form has been known here as *nipae.* Ferris and some other workers, however, believe that there is only one species here, and that is *nipae.* There are those who hold that the *Pseudaphycus* parasite of *nipae* does not attack *pseudonipae* and that as a result of parasite and predator attacks *nipae* had disappeared from Hawaii before 1927. The minutes of the Hawaiian Entomological Society from about 1923 to 1927 contain numerous references to the decline of *nipae* and the great effectiveness of the parasite *Pseudaphycus utilis.* Timberlake (1927:548) stated that *Pseudaphycus utilis* brought about the "spectacular control" of *nipae,* "which for many years had been a bad pest on avocado, fig, mulberry, guava and banyan trees." At the beginning of the century the attacks of this mealybug were so bad that it was called avocado or alligator pear blight. Van Dine (1906:1) stated that "Besides great injury and disfigurement caused by this mealybug to the foliage, fruit and leaf buds, and terminal branches of the avocado, the pest infests the fig, grape, guava and breadfruit." No such infestations have been reported during the past 20 or more years. Several local observers say that they have not seen white *nipae* for many years, although they collect and report minor infestations of the yellow *pseudonipae* not infrequently. Dr. Swezey tells me that one cannot now describe adequately the severity of attack and abundance of *nipae* at the height of its prevalence here. He says that guava bushes were so badly infested that upon passing through a guava thicket one would become smeared with honeydew from the infested plants. He says that a resident took up the

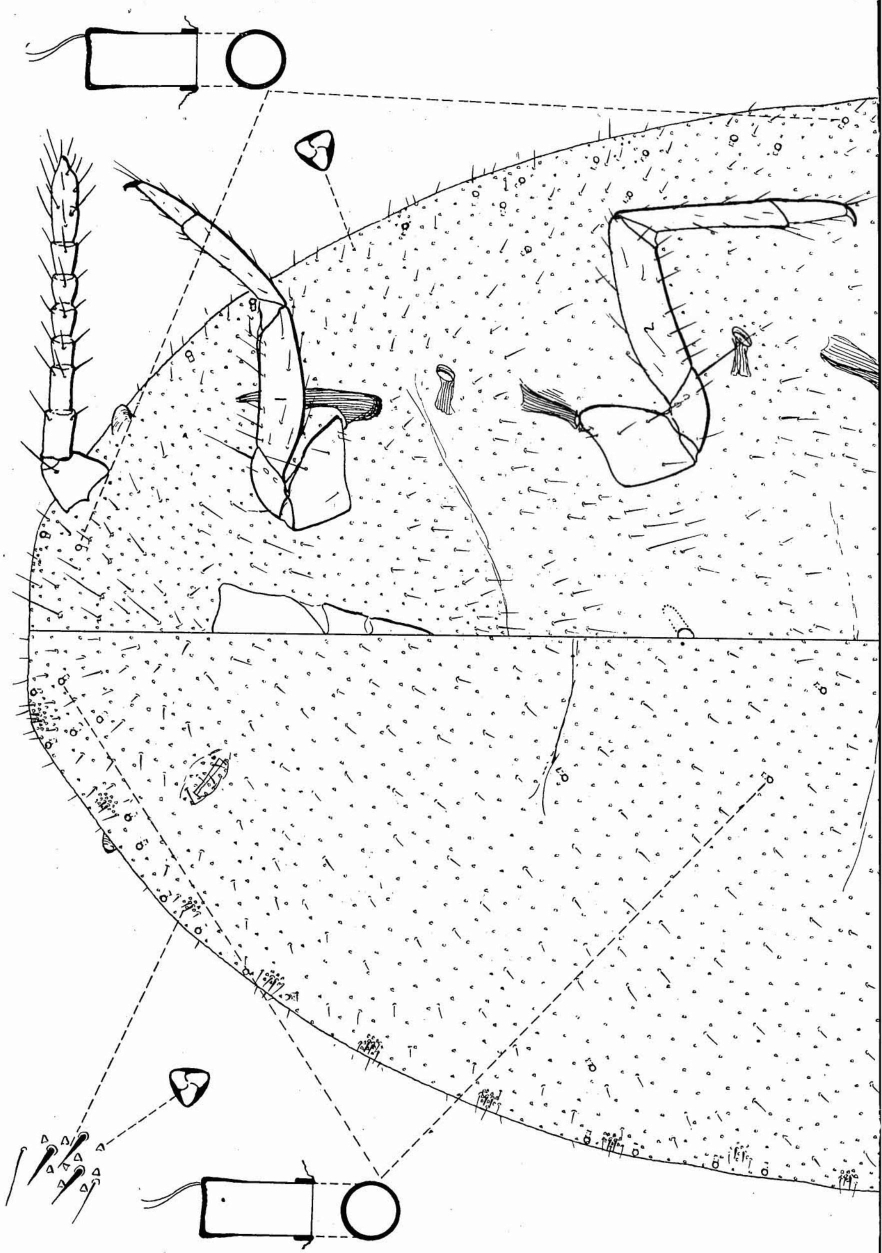
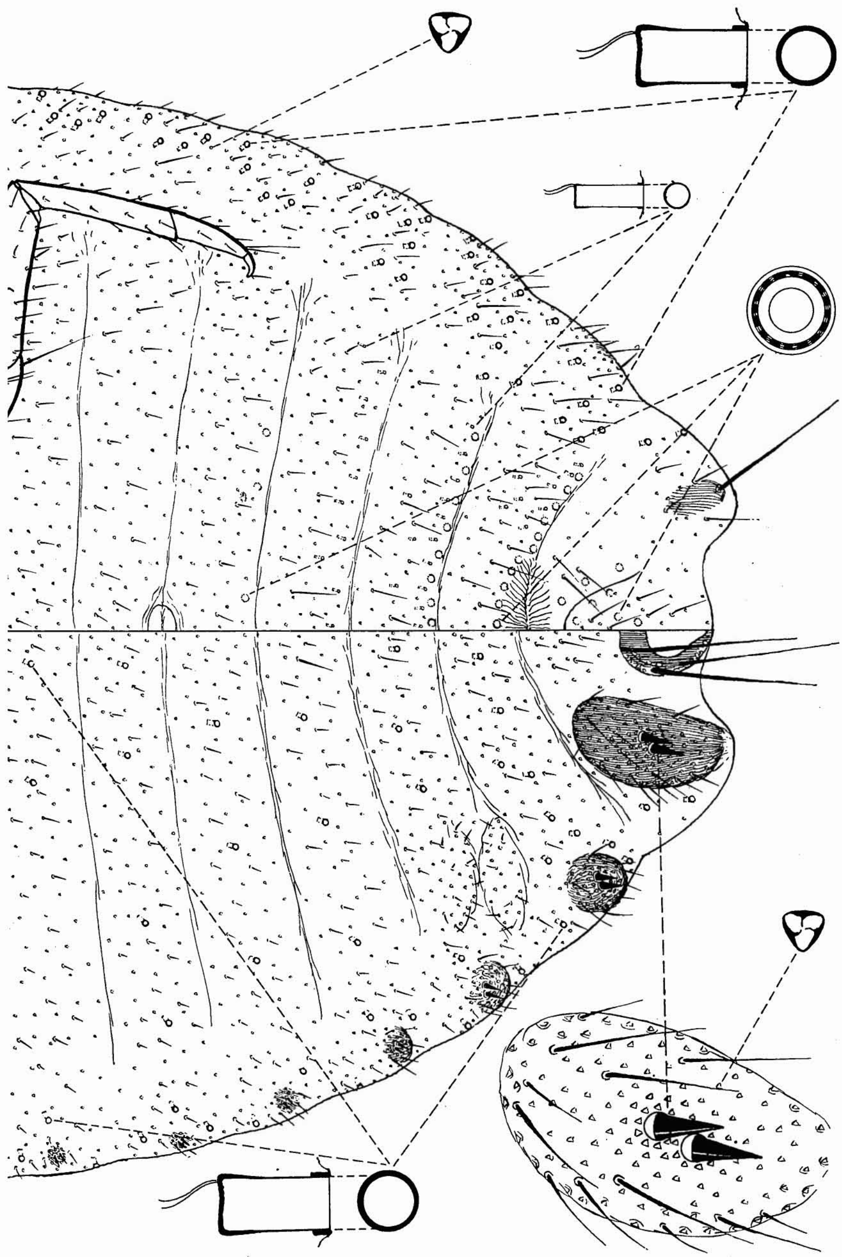


Figure 126—*Pseudococcus montanus* Ehrhorn. (Drawn by Ferris.)



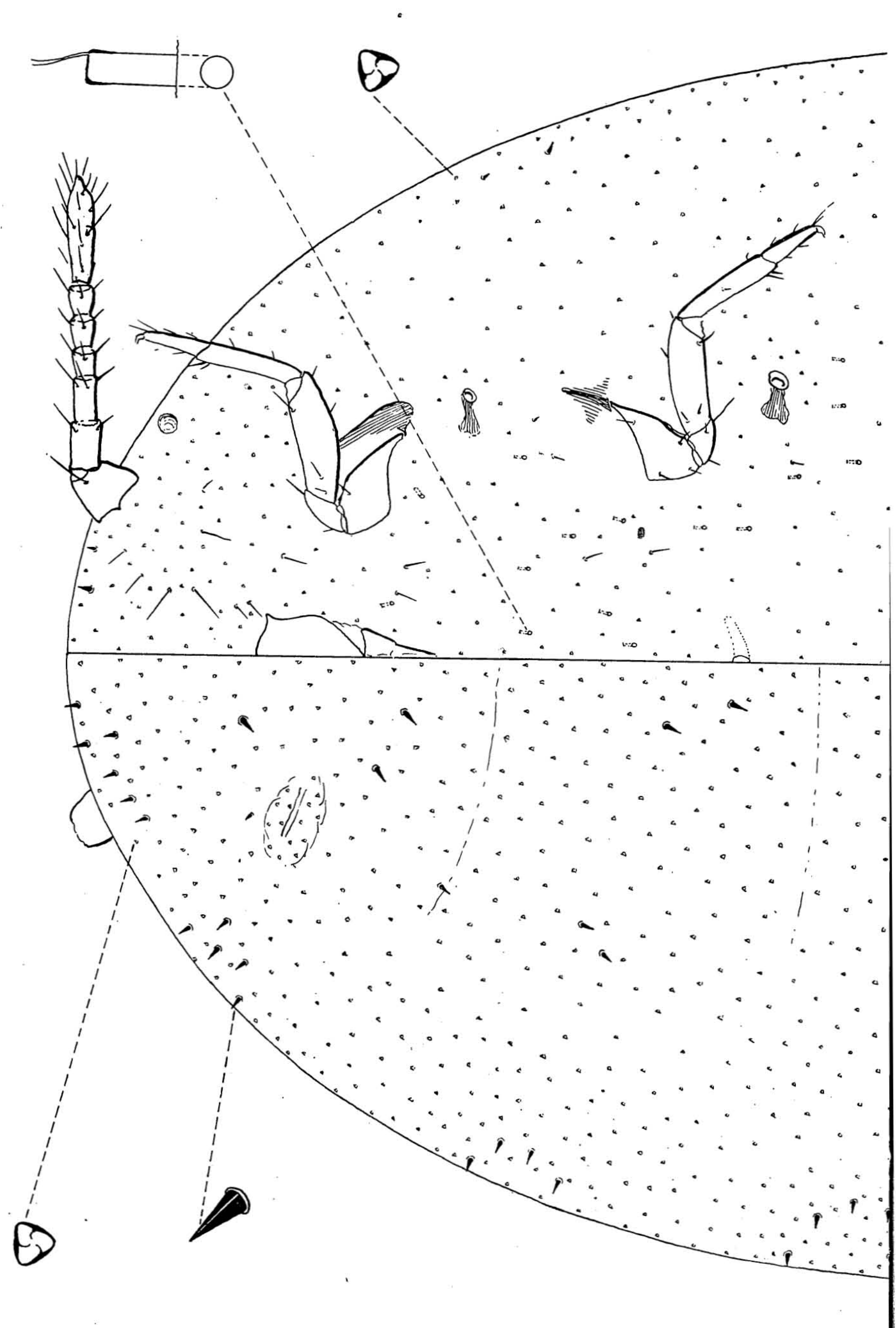


Figure 127—*Pseudococcus nipae* (Maskell). (Drawn by Ferris.)

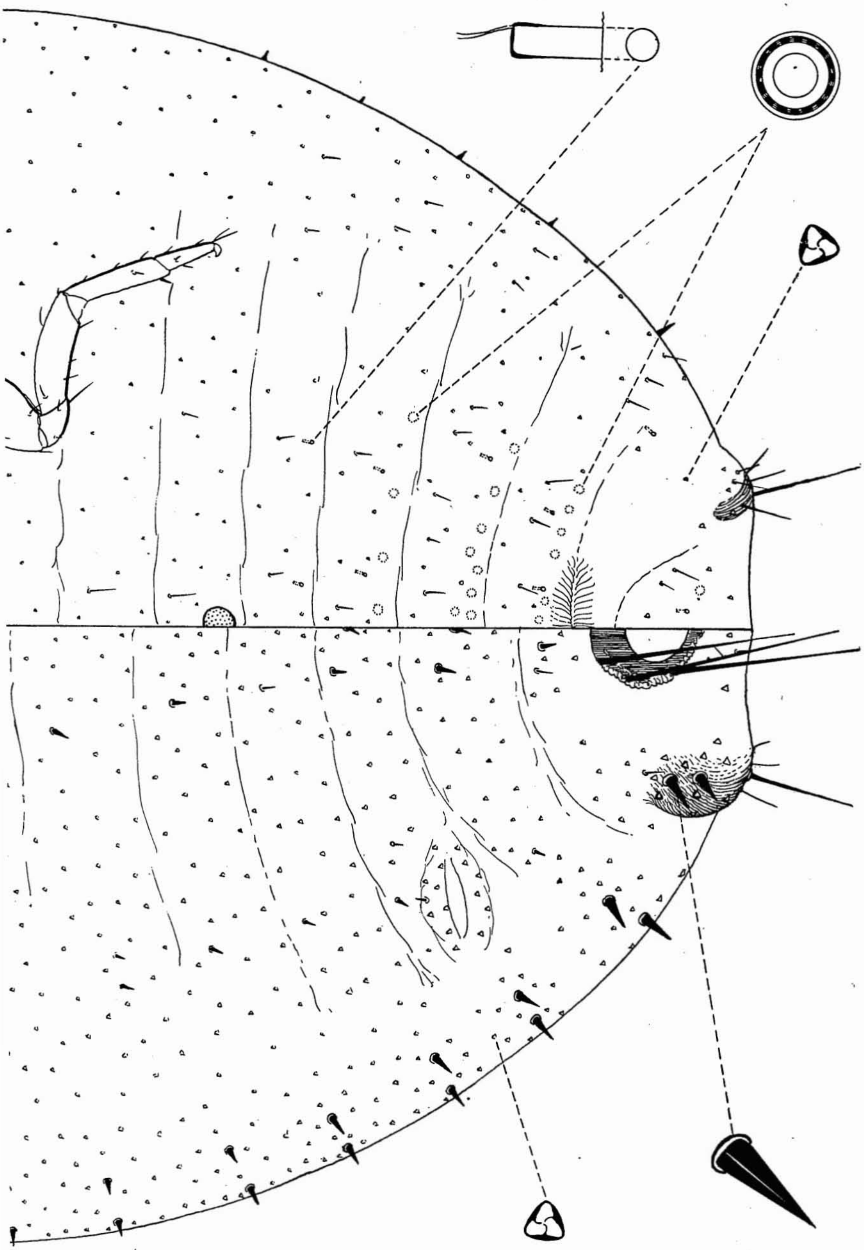


Figure 128—*Pseudococcus nipae* (Maskell).

spraying of avocado trees for $5.00 per tree, and that avocado, fig, mulberry and guava were especially hard hit by the "blight."

We must leave the answer to the problem of whether these two forms are, or are not, the same species to coccidologists. Could there have been two forms here, one of which was not susceptible to the parasitic attacks of *Pseudaphycus utilis* but both of which, when examined microscopically, appeared morphologically identical? Or is the situation in regard to the great reduction in numbers and damage done of similar nature to that of *Icerya* and other coccids which have come under such excellent biological control?

Ferris remarks as follows:

This species is one of a number in which the body contents are of a blue-green color and the derm tends to be more or less pigmented at maturity. Whether or not these species represent a biological group remains to be determined.

The distinctive characteristics of the species are to be found in the following features: Dorsal setae few, of various sizes but all—except perhaps a very few which are extremely minute—stout conical. Cerarii definitely recognizable only along abdomen, anterior to this giving way to irregular groups of conical setae. Abdominal cerarii each with but two conical setae and no cluster of pores, setae of each pair tending to become quite widely separated at maturity. Anal lobes slightly sclerotized, bearing only a very few trilocular ducts which are not clustered about the conical setae. Multilocular disc pores few, restricted to posterior half of

abdominal venter. Tubular ducts present only on venter of thorax and abdomen, few and quite small. Circulus present, but small and inconspicuous and difficult to find in pigmented specimens.

Various people have believed that there are two species of this type, but in the material at hand, which contains specimens from various hosts and localities and including avocado in the Hawaiian Islands and palms from various places, there is no suggestion of any morphological differences.

Pseudococcus nudus Ferris, new species (fig. 129).

Host and distribution: An endemic species from *Dubautia*, Haleakala, 9,700 feet, Maui, T. H., April 25, 1945, E. C. Zimmerman, collector.

Habit: Type material beaten from host; no other details available.

Recognition characters: Length of available specimen (on slide) 2 mm. Antennae seven-segmented. Circulus lacking. Cerarii reduced in numbers, those along thoracic margins either absent or with setae so small and widely separated that they cannot be recognized, there being in available material only about 13 recognizable pairs. Anal lobe cerarius with two quite stout conical setae and several slender hairs, these borne in a small but sharply defined sclerotized area, with numerous pores concentrated about bases of the conical setae. Penultimate cerarius with conical setae somewhat smaller, with two or three slender setae and a small cluster of pores, these not surrounded by sclerotization. Anterior to this the setae become smaller until along thorax they are very small and without a cluster of pores. Frontal cerarius with three very small, conical setae, two or three slender setae and a small cluster of pores. Dorsum without tubular ducts, except for a few with an oral rim, these probably variable, but there being one slightly removed from each of most cerarii. Trilocular pores few. Dorsal setae relatively few, of various sizes but all slender and small.

On ventral side a quite distinct sclerotized area at base of anal lobe seta. Multilocular disc pores extremely few, scarcely more than six about vulva in available specimen. Tubular ducts likewise extremely few, merely a few in regions behind and just anterior to vulva, these all small and with a slight oral collar. Trilocular pores sparse. Setae few, of various sizes but all small and slender. Legs of no distinctive character.

Notes: This is an extremely featureless little species, but the presence of the dorsal, submarginal series of oral rim ducts, the absence of the circulus and the distinct dorsal sclerotization of the anal lobes seem to distinguish it. It is very close to the species herein described as *Pseudococcus mendiculus*, but the latter lacks oral rim ducts. Only one specimen has been available for examination.

The type is in the Bishop Museum.

Pseudococcus palmarum (Ehrhorn) (figs. 130, 131).

Ripersia palmarum Ehrhorn, 1916:245.

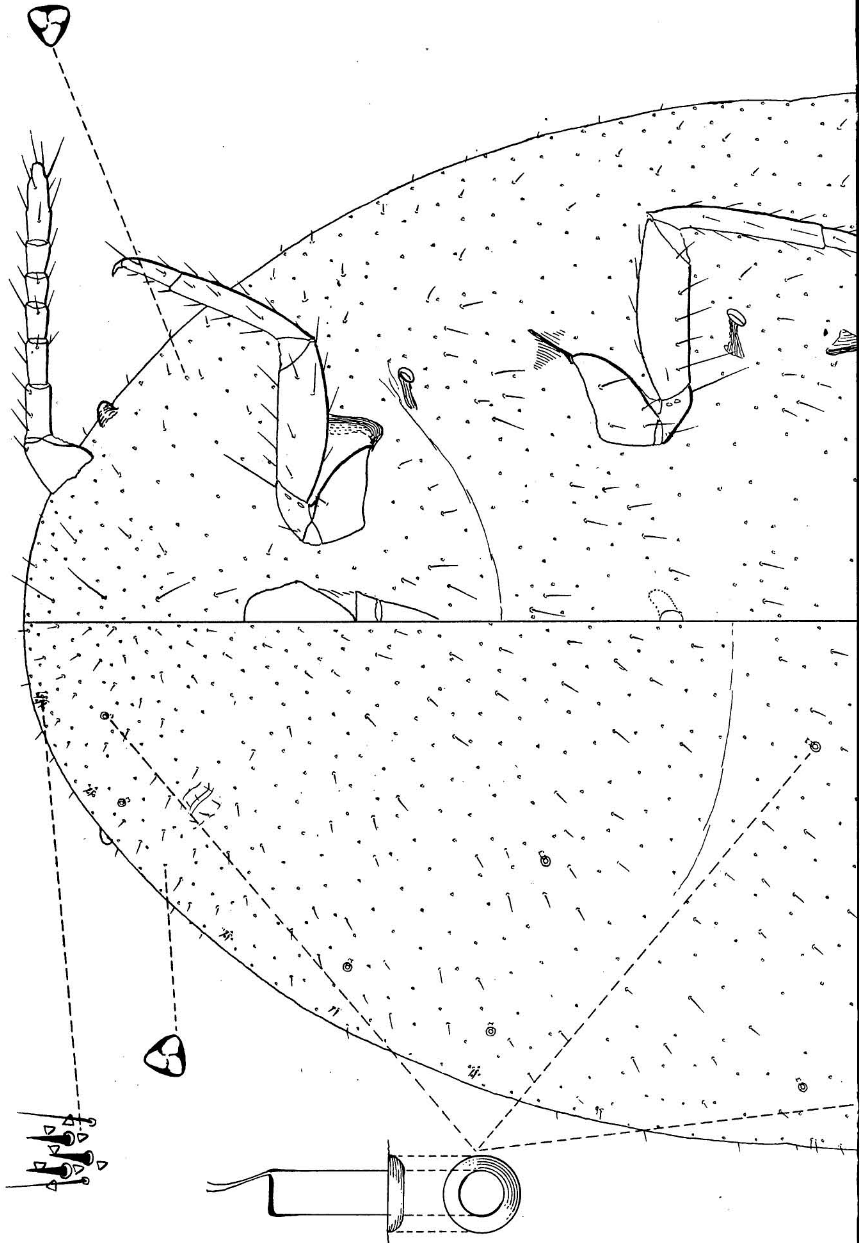
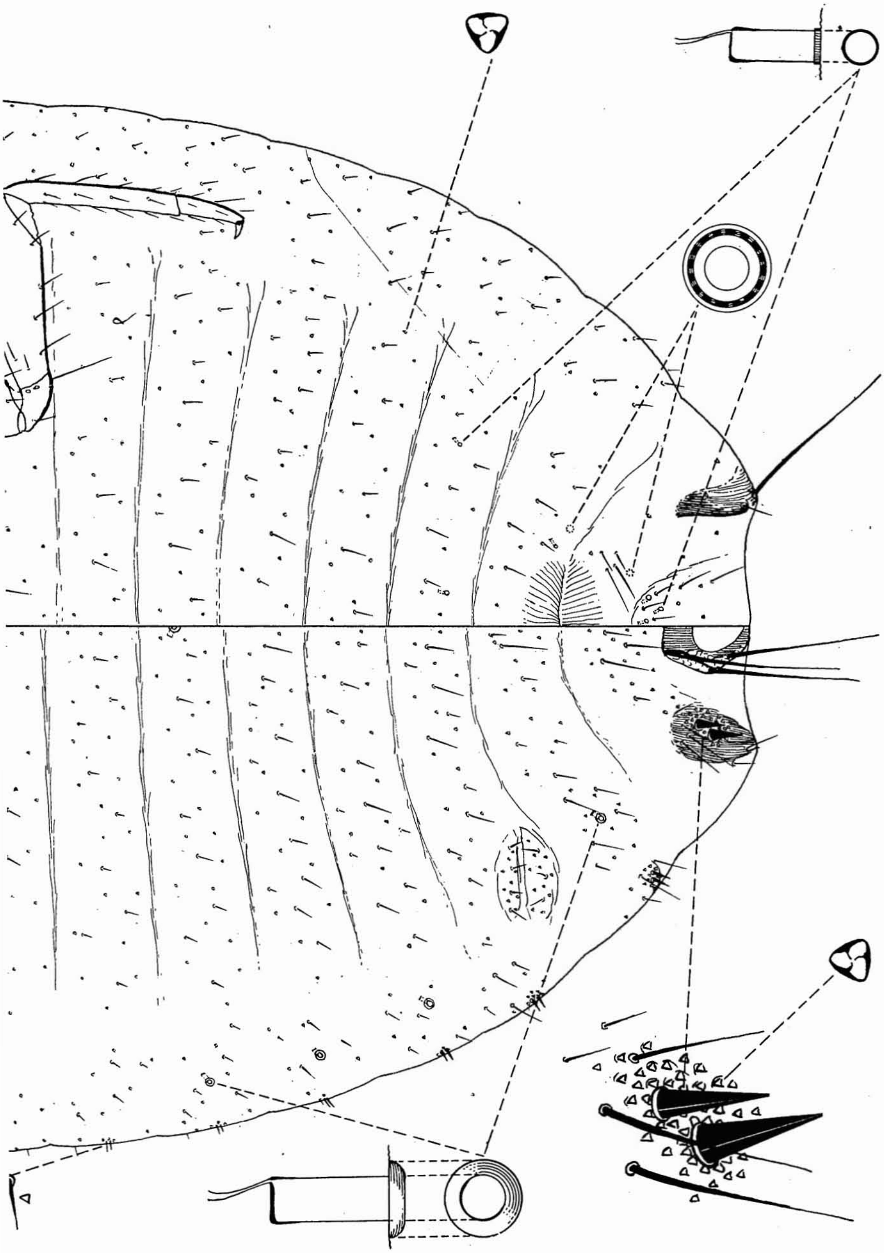


Figure 129—*Pseudococcus nudus* Ferris, new species. (Drawn by Ferris.)



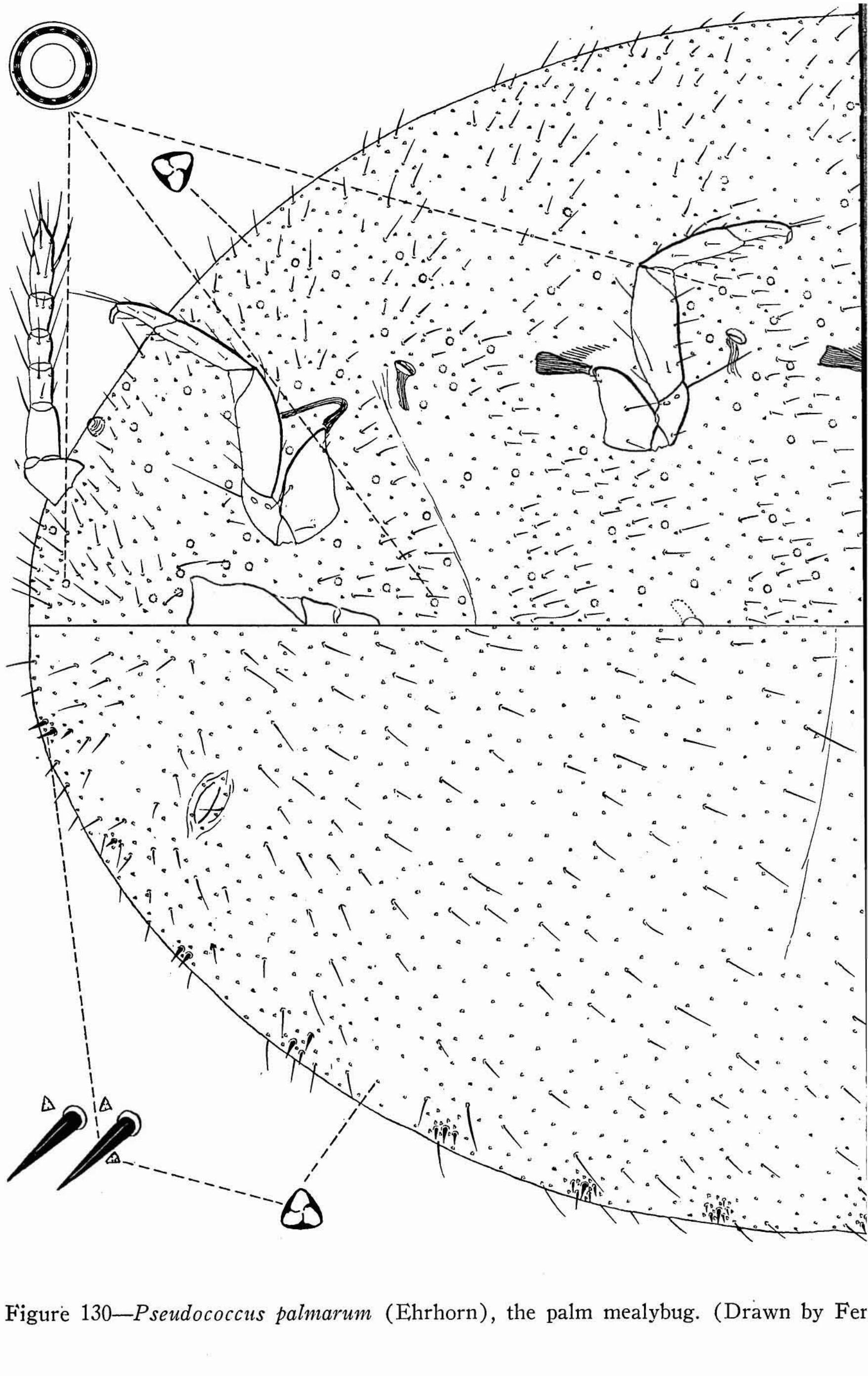
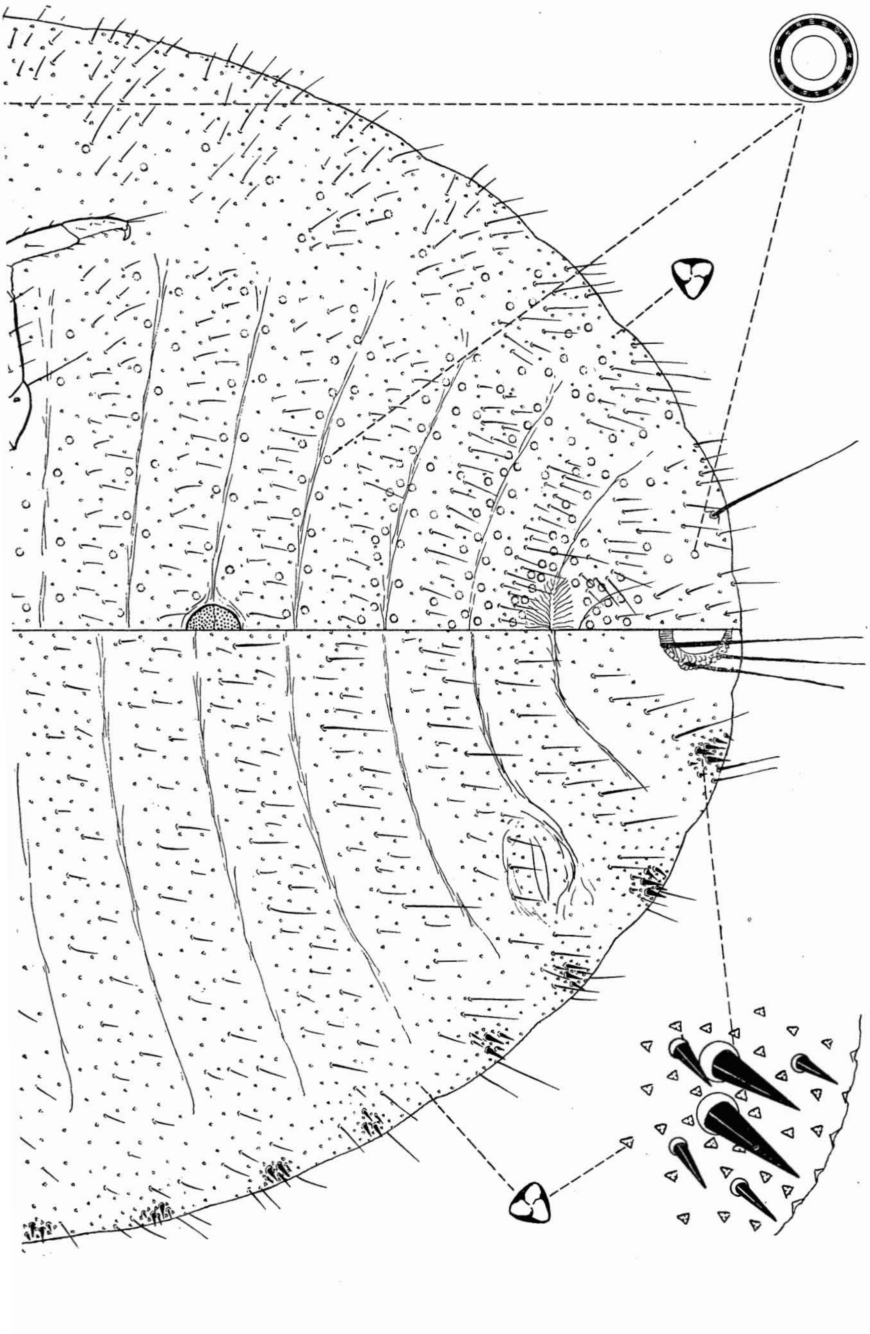


Figure 130—*Pseudococcus palmarum* (Ehrhorn), the palm mealybug. (Drawn by Fer



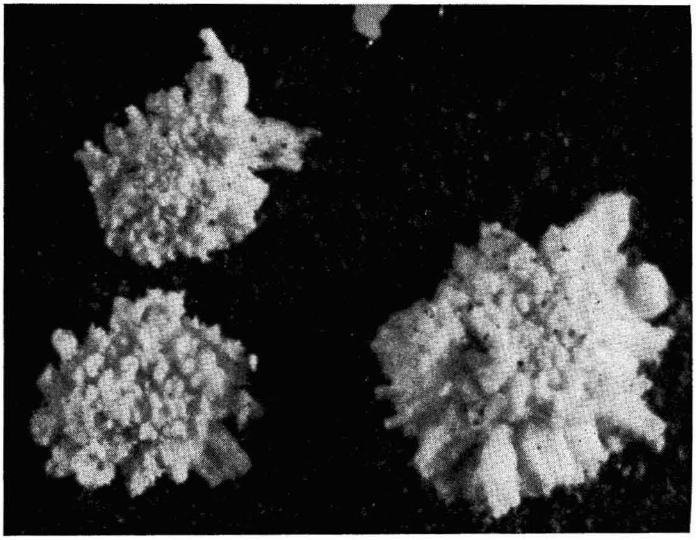


Figure 131—*Pseudococcus palmarum* (Ehrhorn), the palm mealybug.

The palm mealybug.

Kauai, Oahu (type locality: Honolulu).

Immigrant. Evidently a western Pacific form. It may be the same as *oceanicus* Takahashi.

Hostplants: *Chrysalidocarpus lutescens* (*Areca*), coconut, *Latania loddigesii* (*glaucophylla*), *Ravenala* ("travelers' palm"), royal palm, *Thrinax*.

Parasite: *Anagyrus nigricornis* Timberlake (Hymenoptera: Encyrtidae).

Predator: *Gitona perspicax* (Knab) (Diptera: Drosophilidae).

"Adult female viviparous, pale reddish brown, about 3 mm. long, inclusive of caudal setae. Dorsum covered with dense white secretion, hiding segmentation. Marginal tufts very short but stout, getting longer caudad. Eight tufts at caudal end about 1 mm. long. These are sometimes curved upwards; sometimes they coalesce, forming plates which are very farinaceous." (Ehrhorn, 1916:245; from original description.) Both apterous and winged males have been studied.

Although this species has been found abundantly on a number of palms, it does not cause serious damage here.

Browne (*Proc. Hawaiian Ent. Soc.* 10(2):196, 1939) stated that he had found this species seriously attacking the roots of tomatoes and killing about one-half of a commercial planting. His report is believed to be the result of an error in identification. I have been unable to trace or examine his material.

The following notes are by Ferris:

In its typical form this species is marked by the following characteristics: Antennae quite short, normally six-segmented but somewhat variable and at times seven-segmented. Fourteen or fifteen definite cerarii present, those in region of eye tending to drop out or to be represented by a single conical seta. Each cerarius with two larger conical setae of same size and from one to four or even more

smaller conical setae and a slight concentration of trilocular pores. Tubular ducts of any kind apparently lacking. Multilocular disc pores confined to venter, but present from terminal segment to head. Circulus present, rather small, circular, extending across intersegmental line.

Two specimens which are at hand from coconut palm in the Tonga Islands seem to be this species but differ in having most of the cerarii with but two large conical setae and no, or but one, smaller conical seta. It is possible that there is more than one species of this general type.

The accompanying figures are from specimens from *Latania glaucophylla,* Honolulu, received from E. M. Ehrhorn.

This species was referred by Ehrhorn to the genus *Ripersia* because of the six-segmented antennae, but no one knows what *Ripersia* really is, and in its other characters the species is referable to *Pseudococcus.*

Pseudococcus straussiae Ehrhorn (figs. 132, 133).

Pseudococcus straussiae Ehrhorn, 1916:237, 239. Swezey, Proc. Hawaiian Ent. Soc. 9(1):6, 1 fig., 1935.

Oahu (type locality: Mount Tantalus), Molokai.

Endemic.

Hostplants: *Charpentiera obovata, Gouldia, Myrsine, Straussia kaduana, Straussia hawaiiensis. Straussia* is, of course, the type host.

Parasite: an undescribed native species of *Anagyrus.*

This is a distinctive-appearing mealybug, as the photograph clearly demonstrates. It is not often seen. The ovoviviparous adult females are pale yellowish-green in body color, and the lateral and caudal wax filaments are slender and long; the caudal ones may reach a length of 6 mm. The individuals occur in colonies on the undersides of the leaves, and the areas occupied by them are dusted with white wax.

Professor Ferris, who states that he has never seen a mealybug similar to this one, writes as follows:

This is a readily recognizable species. Body elongate and slightly, but distinctly, pyriform, the cephalic end being the smaller. Fourteen or fifteen pairs of cerarii present, the missing two or three being those just behind the eyes. All the cerarii much alike, each with two quite stout conical setae, at least two or three slender setae and a closely set cluster of trilocular pores. Circulus quite large, circular, very delicately bordered. In some old mounts it has faded so as to be invisible or extremely faint. Tubular ducts of any kind either entirely lacking or exceedingly few and small—apparently lacking. Multilocular disc pores lacking. Trilocular pores sparsely distributed over dorsum, region of vulva, and lateral areas of venter, apparently lacking over entire median region of venter from head to just in front of vulva. The trilocular pores are of a peculiar type, being slightly trifoliate.

The drawing of this species was made before fresh material was obtained, and the circulus has been omitted from the drawing (E.C.Z.).

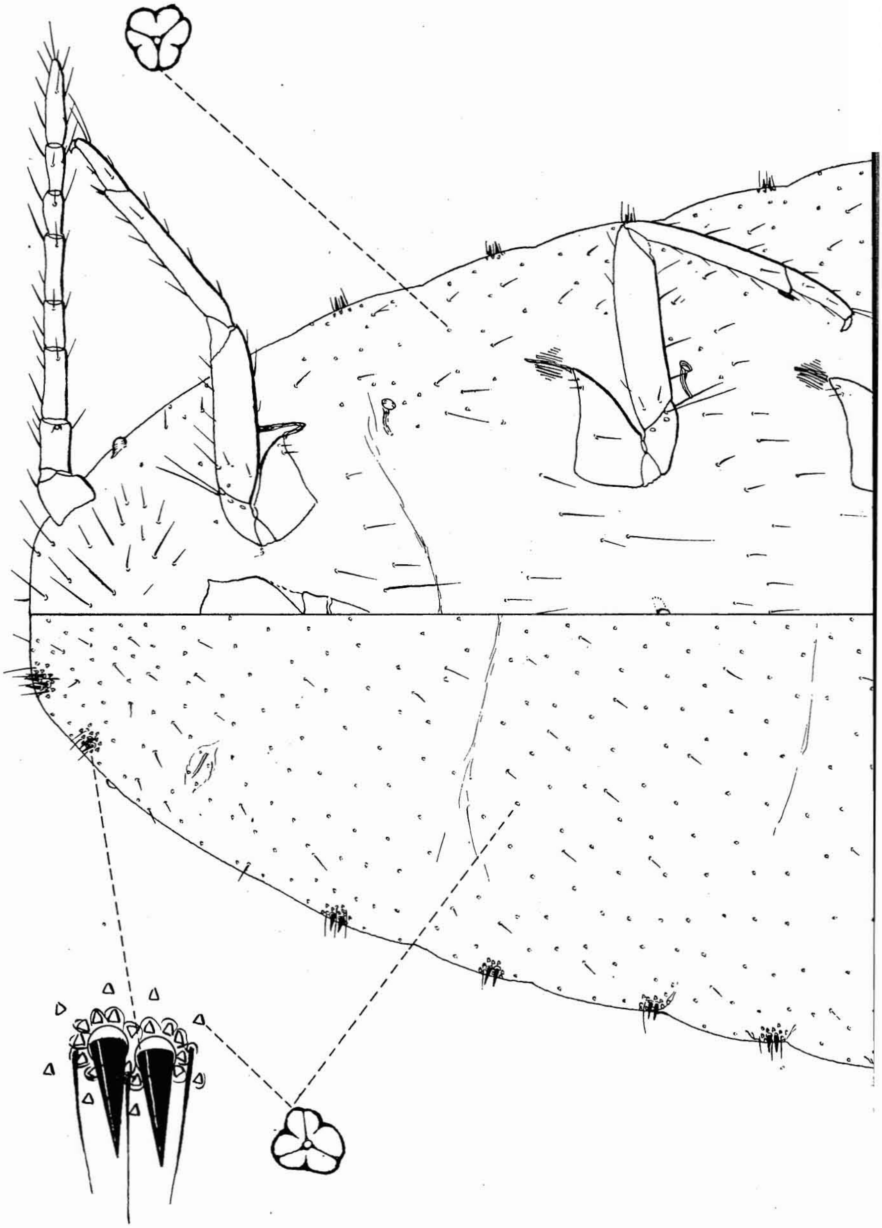
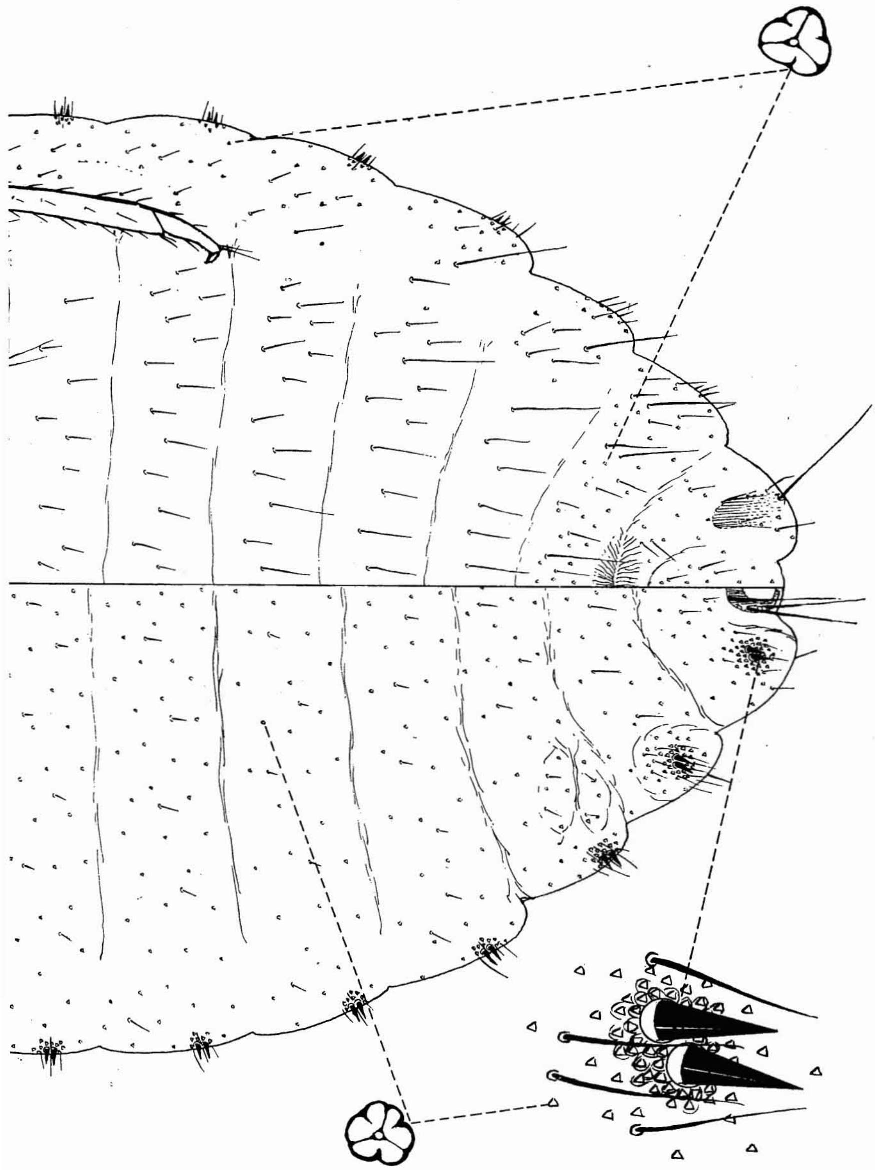


Figure 132—*Pseudococcus straussiae* Ehrhorn. (Drawn by Ferris; the circulus has bee omitted from this drawing.)



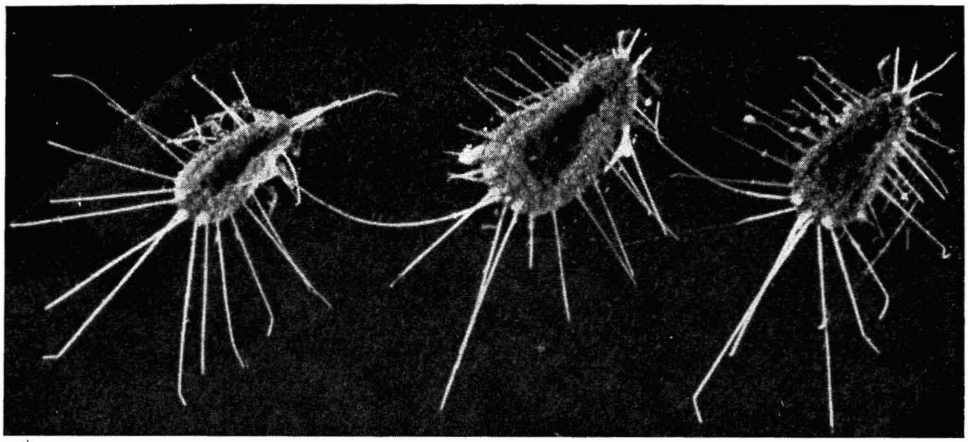


Figure 133—*Pseudococcus straussiae* Ehrhorn (shriveled from drying).

Pseudococcus swezeyi Ehrhorn (fig. 134).
Pseudococcus swezeyi Ehrhorn, 1916:237, 240.

Swezey's mealybug.

Endemic. Kauai, Oahu (type locality: Mount Tantalus), Maui.

Hostplants: *Acacia koa, Dianella odorata* (?), *Sida* ("ilima") (?).

Ehrhorn (1916:240) described the pinkish-brown adult female, but his description does not agree with the specimens in figure 133 which were collected and identified by Swezey. This species causes folding of the leaves of *Acacia koa.* I question the other host records.

Ferris supplies the following data:

This is one of the group of species (to which *P. montanus* Ehrhorn also belongs) all members of which have a sclerotized area about both the anal lobe and penultimate cerarii. It may be recognized by the following combination of characters: Sclerotized area about anal lobe cerarius rather small but well developed, pores concentrated closely about cerarian setae and forming a slightly depressed area. Penultimate cerarius with a small sclerotized area and likewise with pores concentrated about the setae. Cerarii anterior to this with setae becoming very small and tending to disappear entirely in midregion of body, there sometimes being only 15 definite cerarii present. Dorsum of body with scattered tubular ducts which are moderately large and each with a definite raised rim about mouth. A very few smaller tubular ducts without raised oral rim present on venter of abdomen. Multilocular disc pores extremely few, scarcely a dozen, and these confined to area immediately around vulva. Circulus present, quite large and distinct. Legs and antennae noticeably short.

The records of this species by Ferris (1935:127) from the Marquesas Islands and Tahiti are based upon misidentifications. The specimens in question definitely do not represent *swezeyi.* They may be separated immediately by the fact that in them the circulus is lacking. Their identity is unknown.

Pseudococcus tympanistus Ferris, new species (fig. 135).

Hosts and distribution: From undetermined tree, near Puu Luau, Haleakala, Maui, Hawaii, April 27, 1945, E. C. Zimmerman.

Habit: Beaten from the host; evidently rare; no notes available. (E.C.Z.)

Recognition characters: Length (on slide) about 3.75 mm. Antennae eight-segmented. Circulus present, small, but distinctly developed. The immediately distinctive feature of the species is the presence of numerous structures, apparently tubular ducts, over entire dorsum and in the lateral areas ventrally. These take the form of an invagination, which is about as broad as it is deep, its breadth being equal to three or four times that of a multilocular disc pore. There is no suggestion of the inner filament which is characteristic of the tubular ducts of the Pseudococcidae, the inner end apparently being entirely closed. Viewed laterally the structure has the appearance of a drum, which has suggested the specific name. It has a slight oral collar, so that viewed end-on it appears as a sclerotized ring.

Cerarii reduced in numbers, recognizable only along abdomen and on head, there being only seven or eight identifiable pairs in available specimens. Anal lobe cerarius with two quite large conical setae and several slender setae, these borne in a large and definitely defined sclerotized area which bears numerous pores over its entire surface, these being only slightly concentrated about the conical setae. Penultimate cerarius with conical setae somewhat smaller, accompanied by several slender setae and a cluster of pores but without accompanying sclerotization, and the remaining abdominal cerarii similar but with conical setae somewhat smaller. Frontal cerarius with three or four very small, conical setae, as many slender setae and a few pores. Ducts lacking on dorsum except for large ducts described above. Trilocular pores normally numerous. Setae rather sparse, of various sizes, but all slender.

On ventral side there is a distinct, sclerotized area at base of each anal lobe seta. Multilocular disc pores relatively few, perhaps as many as 30–40 concentrated about immediate region of vulva. Small tubular ducts with an oral collar present in very small numbers on abdominal venter between vulva and circulus. Setae numerous, of various sizes, but all slender. Legs of no distinctive character.

Notes: While in all of its common features this is a quite ordinary species, the relatively enormous, drum-like ducts are utterly unlike anything that has ever been described for any species of *Pseudococcus* and permit the immediate recognition of the species. The type slide is in the Bishop Museum.

Pseudococcus vastator (Maskell) (figs. 136, 137).

Dactylopius vastator Maskell, 1895:65, pl. 6, figs. 12–16.

Dactylopius perniciosus Newstead and Willcocks, 1910:138, fig. 10.

Pseudococcus filamentosus, in part, misidentification by Fernald, 1903:101.

Pseudococcus filamentosus, misidentification by Lindinger, 1912:52, 63, 165.

Pseudococcus filamentosus, misidentification by Fullaway, 1909:13–16, figs. 7, 8. Ehrhorn, Proc. Hawaiian Ent. Soc. 3(2):70, 1915, and 1916:237.

Pseudococcus perniciosus (Newstead and Willcocks). New synonym.

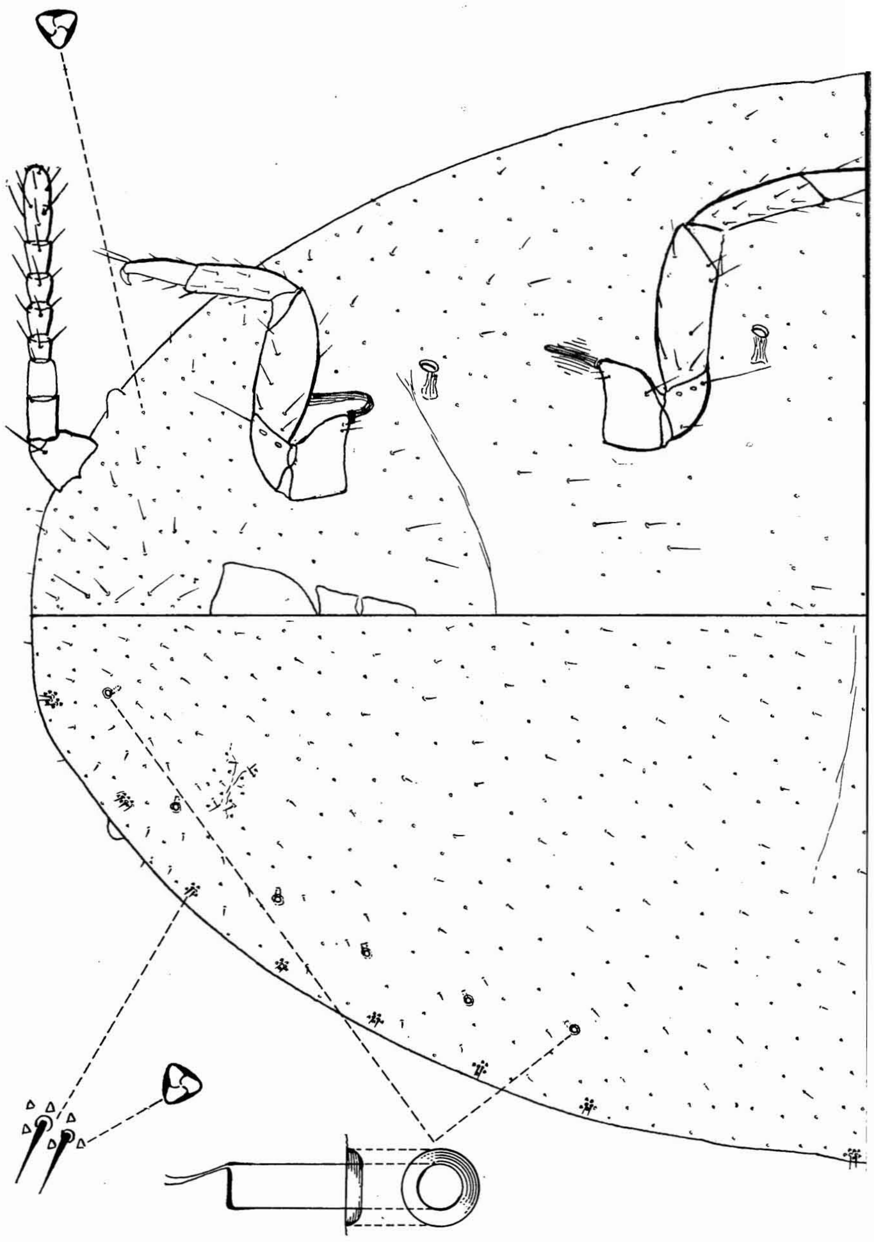
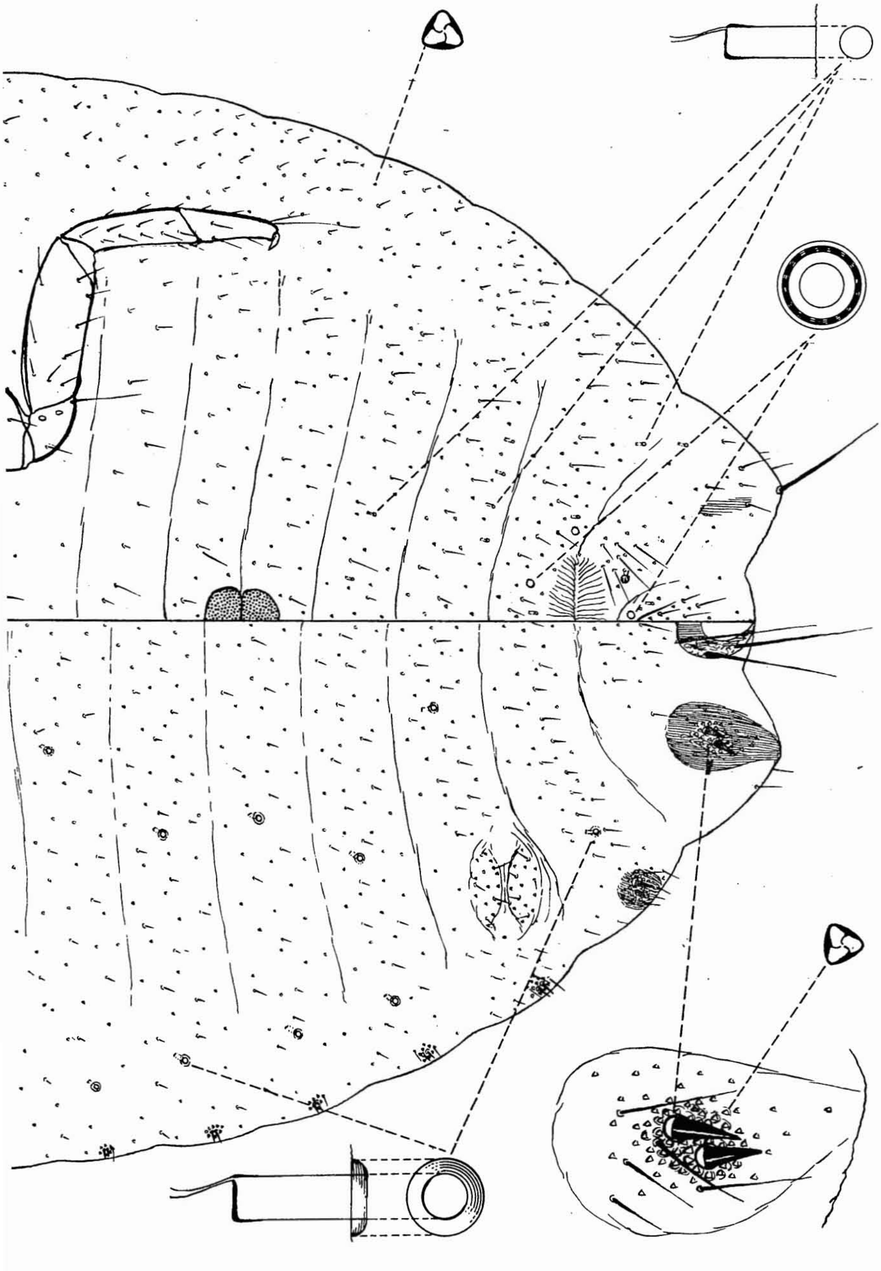


Figure 134—*Pseudococcus swezeyi* Ehrhorn, Swezey's mealybug. (Drawn by Fer



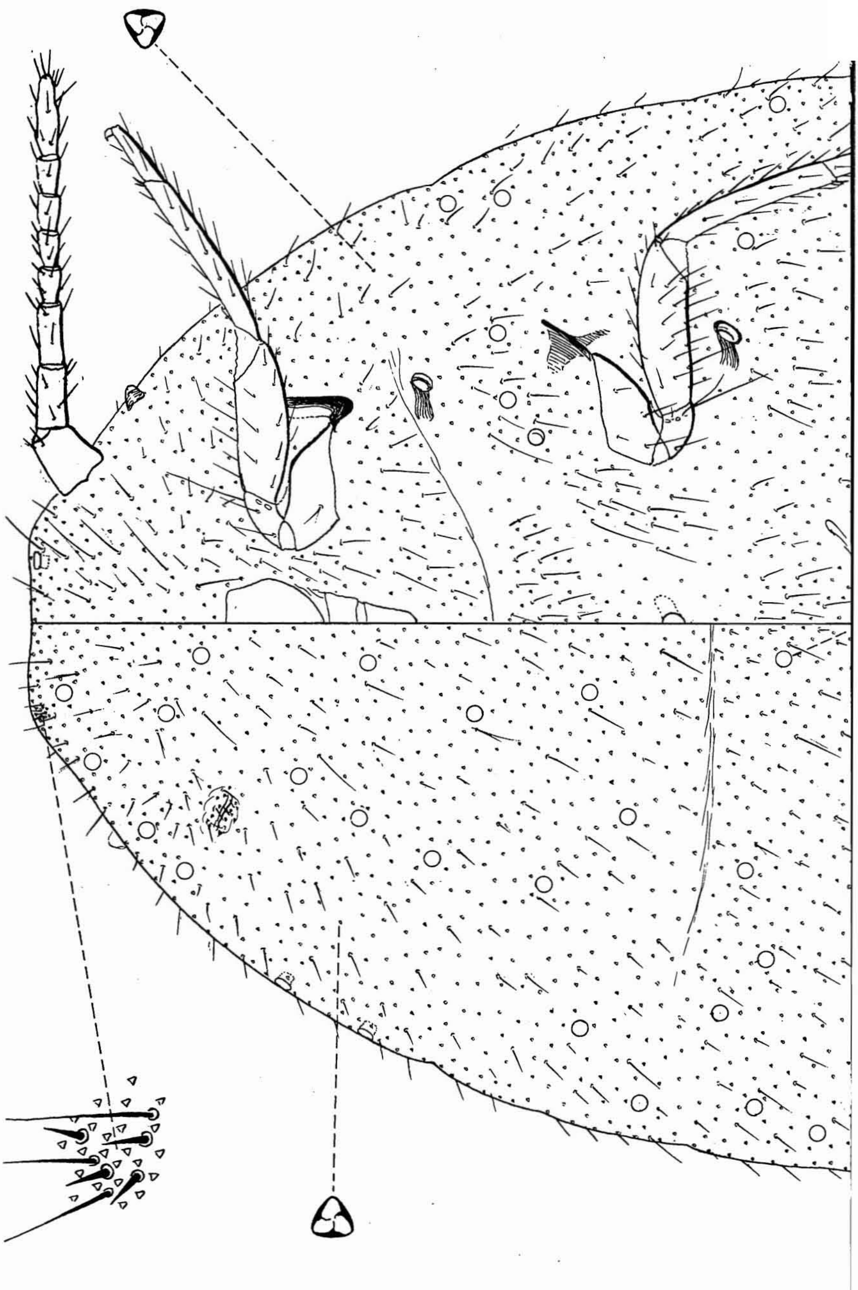
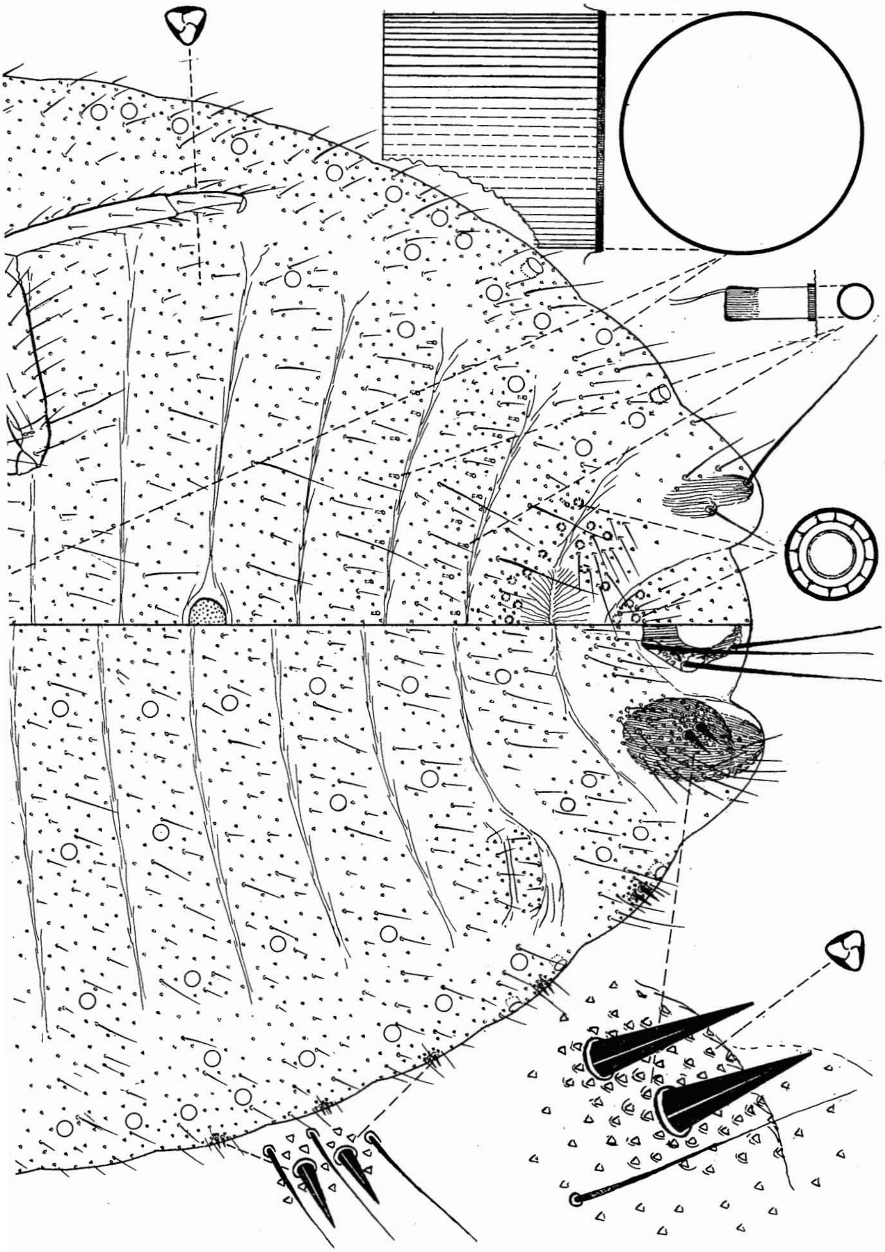


Figure 135—*Pseudococcus tympanistus* Ferris, new species. (Drawn by Ferris.)



Oahu, Hawaii.

Immigrant. A widespread species; described from Hawaii. This was first noticed at Honolulu by Koebele about 1891, and he considered that it had been introduced from Japan.

Hostplants: *Ceratonia,* various kinds of *Citrus,* cotton, *Gossypium tomentosum,* grape, *Hibiscus, Hibiscus arnottianus,* mulberry, tamarind.

Parasites: *Anagyrus dactylopii* (Howard) (Hymenoptera: Encyrtidae). This effective parasite was introduced from Hong Kong by Fullaway in 1925.

Predators: *Cryptolaemus montrouzieri* Mulsant, *Scymnus bipunctatus* Kugelann, *Scymnus uncinatus* Sicard (Coleoptera: Coccinellidae); *Gitona perspicax* (Knab) (Diptera: Drosophilidae).

This species has in the past caused much damage in Hawaii. It seriously injures the terminal buds of orange, causing these to become malformed, curled and dwarfed, and I have seen it badly deforming and killing out the terminals of the native *Hibiscus arnottianus.* Maskell (1895:66–67) quotes from letters from Koebele as follows: "It has been introduced from Japan within the last three years, and hundreds of trees have been destroyed by it in Honolulu. . . . It is not confined to *Citrus* trees, but attacks almost any kind of shrubs and trees. For this reason no plants were allowed to leave Honolulu for the other islands for nearly two years. I have seen no Coccid that is so destructive to trees as this species. During the summer the trees were actually loaded down with *Dactylopius.* . . . Fortunately the danger is over now, as we are sending out colonies of the best enemy for the same that can be found in Australia." The species is now under effective biological control.

Willcocks (1910) gives a good, well-illustrated account of the species and its damage to *Albizzia lebbek* in Cairo.

The purple-bodied adult females produce a globular, yellowish or whitish, fluffy, cottony eggsac which nearly, or quite, covers them. The wax processes are heavy. The eggs are purple, several hundred eggs are laid, and these hatch in about 15 days. The larvae are dark red (Fullaway, 1909:13–16, figs. 7, 8) or dark purplish. This species tends to mass in large, dense colonies on its hostplants with the eggsacs so closely combined that it appears that a whole colony is a single irregular bunch of cotton. The "cotton" is stringy and can be drawn out in long spider-web-like filaments (see fig. 137).

The following notes are by Ferris:

Recognition characters: A rather large species, reaching a length of about 4 mm., as mounted on slide. As mounted, broadly oval or slightly pyriform. Derm blue-green at maturity, this color disappearing or altering to a brown or purple at times during course of preparation of specimens, or even disappearing. Antennae rather short, normally seven-segmented. Legs tending to be relatively small, short and stout. Circulus present. Dorsal ostioles very small and inconspicuous at maturity, posterior pair rather difficult to find, anterior pair not discernible in available preparations but possibly present. Cerarii reduced in number, no more than eight pairs being recognizable in material at hand, these on abdominal segments and perhaps metathorax, never present on head. Anal lobe cerarii containing two

quite large, very slightly lanceolate setae and a very small number of trilocular pores, surrounded by a vaguely limited, small, sclerotized area that appears in well-stained specimens. Setae in cerarii anterior to anal lobes becoming progressively somewhat smaller and the two setae of each pair becoming quite widely separated, accompanied by no cluster of pores. Dorsal setae very few, of various sizes but almost all somewhat lanceolate, those in median region of abdominal segments being largest, those of head region tending to be slightly curved. Trilocular pores of dorsum rather sparse; it is possible that in young adults a pattern of distribution could be recognized but this is obscured in fully grown individuals. Tubular ducts of dorsum sparsely distributed, all very small, rather slender and with a collar about orifice but without an oral rim. There may be an occasional multilocular disc pore on dorsum of abdomen, as indicated by one or two specimens, but these seem normally to be lacking.

On ventral side of body multilocular disc pores are abundant in median region of abdomen, from terminal segment to posterior border of metathorax and occur in small numbers in lateral regions as far forward as mesothorax. Tubular ducts, of same size and character as those of abdomen are present in small numbers from terminal segment of abdomen even to region between antennae and are very abundant in lateral areas as far forward as mesothorax. Trilocular pores are very few, especially in abdominal region.

Notes: There has been much confusion between this species and *Pseudococcus filamentosus* (Cockerell). *Pseudococcus filamentosus* was described from the Bahamas in 1893, and *vastator* was described in 1894 from Hawaii. In the Fernald Catalogue (1903) *vastator* was placed as a synonym of *filamentosus* [following the synonymy of Tinsley, 1900:64, E.C.Z.], and because of this synonymy the name has disappeared from the literature. In 1910, Newstead and Willcocks described *Dactylopius perniciosus* from Cairo, Egypt. Through the kindness of Dr. Harold Morrison it has been possible to see specimens from the type material of *filamentosus,* and specimens, which seem definitely to belong to this species, are at hand from Mexico. Specimens have also been received from Newstead from the type locality of *perniciosus.* No type specimens of *vastator* have been seen in connection with this work, but the identity of the species as it occurs in Hawaii seems clear.

It is evident from this material that two species are involved, but that *vastator* is not a synonym of *filamentosus.* Also, *perniciosus* is not a synonym of *filamentosus,* as has at times been suggested, but it is instead a synonym of *vastator.* Consequently, all records under the name *filamentosus* are open to question. It seems possible, for example, that the species described by Green as *Pseudococcus filamentosus* variety *corymbatus* from various hosts in Ceylon is really *vastator.* Credit is due to Mr. Zimmerman for remembering the name *vastator* and rescuing it from oblivion.

The two species, while of the same general type, are easily separable in even moderately good preparations. In *filamentosus,* multilocular disc pores are numerous on the dorsum of the abdomen; tubular ducts are numerous on the dorsum and are short and noticeably broad; the dorsal setae are much more lanceolate and approach an "acorn shape." In *vastator,* there are normally no multilocular disc pores on the

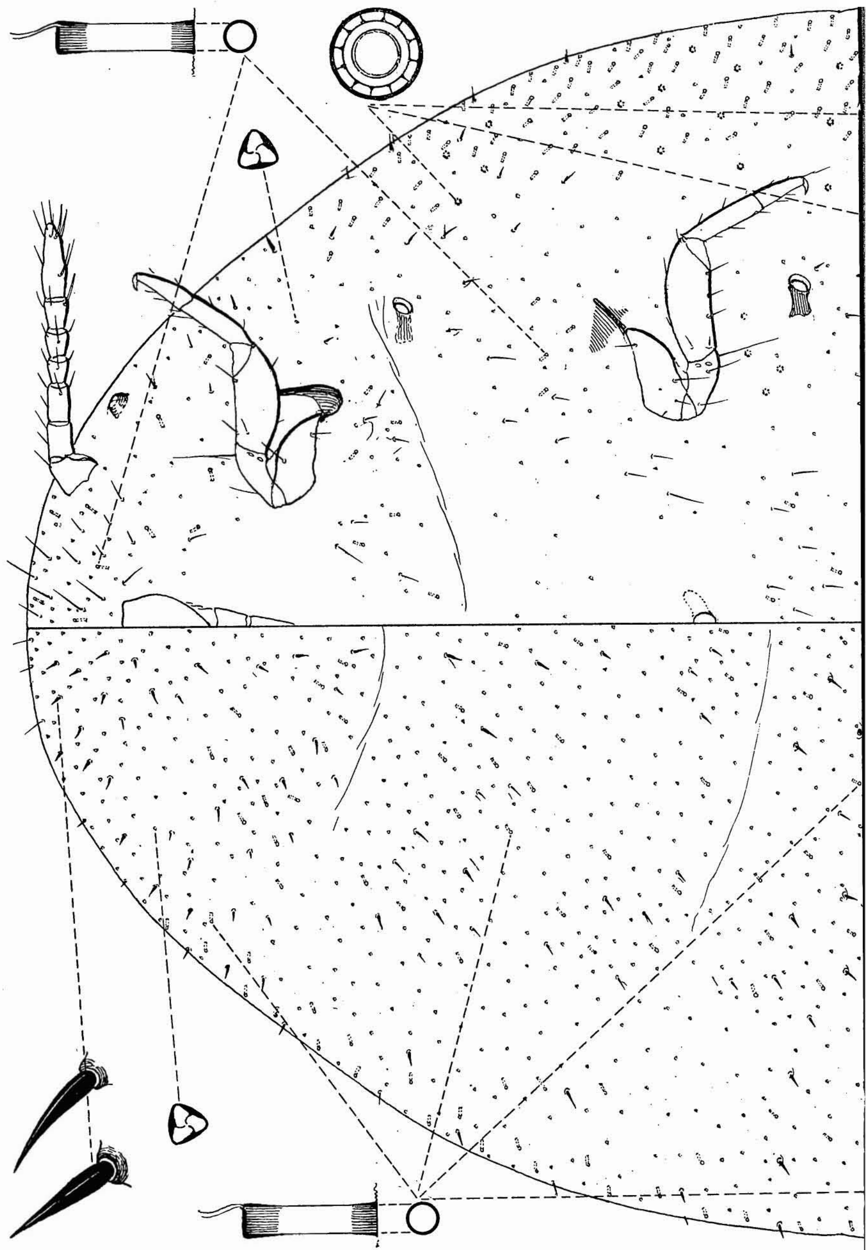
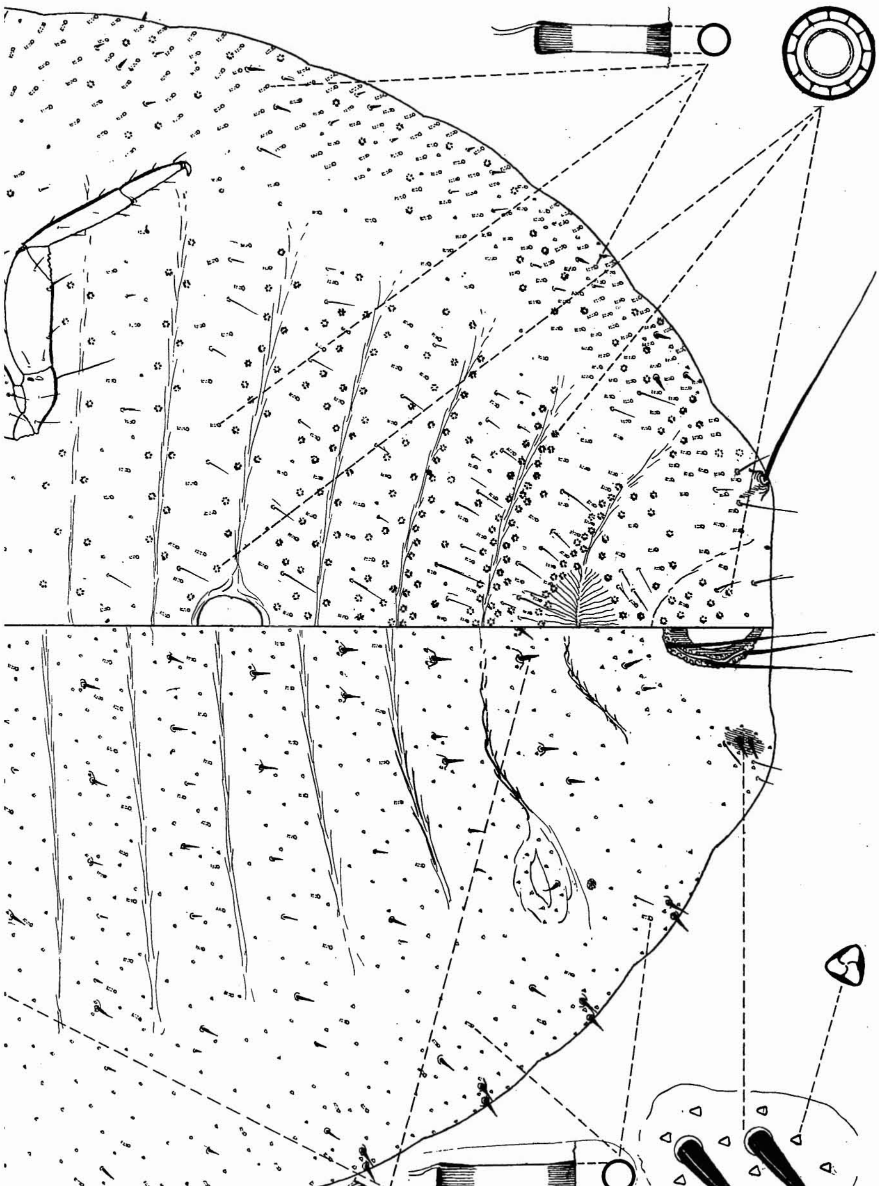


Figure 136—*Pseudococcus vastator* (Maskell). (Drawn by Ferris.)



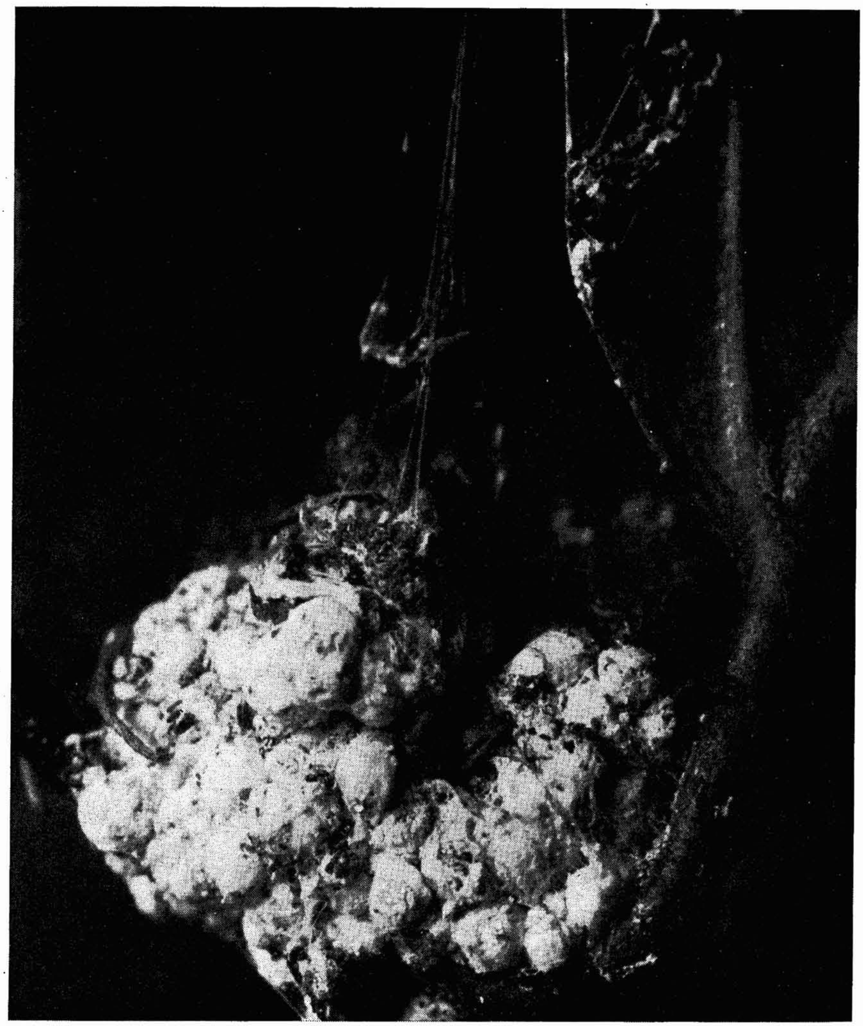


Figure 137—*Pseudococcus vastator* (Maskell) on *Hibiscus arnottianus*. Note the web-like nature of some of the wax.

abdomen; the tubular ducts of the dorsum are all very small and slender; the dorsal setae are more slender and but very slightly lanceolate. The differences do not fall within any range of variation that—in the light of a wide acquaintance with the group—seems at all probable.

Pseudococcus, species indeterminable.

A single fragmentary specimen, bearing the data, "on ohia ha, Tantalus, Oahu, IX-8-'12, Swezey collector," is at hand. This has mistakenly been determined by someone [Ehrhorn, I believe, E.C.Z.] as *Pseudococcus gallicola* (Ehrhorn), which it definitely is not.

This seems to represent a quite distinct species. The posterior end of the body is well preserved. It shows the anal lobe cerarii with a conspicuously large and well-defined sclerotized area about the anal lobe cerarii, with numerous pores clustered about the large conical setae. Penultimate cerarius with the conical setae slightly smaller, with a cluster of pores but without a surrounding sclerotized area. The dorsum shows numerous oral rim ducts and, as a most distinctive feature, there are numerous such ducts in the submarginal areas ventrally near the abdominal cerarii.

The species cannot be described from such a specimen, but it is noted here in the hope that recognition of its existence may lead to the discovery of more material. (Ferris.)

Figure 138—An unidentified species of *Pseudococcus*. This species appears to be a rather recent immigrant to Hawaii, and it might have been confused on occasion with *Pseudococcus brevipes* (Cockerell). Note the masses of young at the edges of the colony, which is on a sunflower stalk.

Pseudococcus, species not identified (fig. 138).

I have collected an immigrant species of *Pseudococcus,* new to the Territory, which we have not been able to identify. A photograph of a typical colony taken about four feet up from the base of a sunflower stalk growing in the shade in my garden, is included here. This species may have been confused with *Pseudococcus brevipes* (Cockerell) by some observers. Other hostplants are *Bignonia unguiscati, Medinella magnifica,* sisal and *Smilax.*

Genus **TRIONYMUS** Berg, 1899

Signoretia Kraatz, 1888.
Westwoodia Signoret, 1875.

This group is closely similar to *Pseudococcus,* from which it has been separated by some coccidologists principally because its members have only one or a few pairs of cerarii (at most three pairs in our species). Perhaps it has been more a genus of taxonomic convenience than a natural monophyletic assemblage. But Professor Ferris has the following notes to add:

Although the limits of this genus remain to be defined, its claim to recognition as distinct from *Pseudococcus* seems entirely valid although, as at present constituted, the genus is certainly a miscellaneous group of species, some of which represent genera at present unnamed.

The type species, *Trionymus perrisii* (Signoret), has been well redescribed by Marchal, and its characteristics are unmistakable. What seems to be the same species occurs in the United States, and specimens of it are at hand. As based upon this and some other species which seem to be congeneric, the characteristics of the genus are as follows:

Pseudococcidae which occur as a rule on grasses and other monocots and are commonly of elongate form, with the anal lobes obsolete or but little produced. Antennae normally eight-segmented but at times with fewer segments. Claw always without a tooth. Circulus, when present, normally quite small, with a strongly defined rim and confined to the fourth abdominal segment, or at least not interrupted by the intersegmental line. Cerarii reduced in number, lacking entirely on the head and thorax and being restricted to the last four or five abdominal segments, or even to the anal lobes.

The absence of the circulus in some species complicates the recognition of the genus at times, but cannot by itself invalidate the assignment of a species to it, since this structure may be present in one and absent in the other of two closely similar species. It is absent in three of our species which seem definitely referable to this genus. In these species, the restriction of the cerarii to the terminal abdominal segments presents the basis for their generic assignment.

One species, *Trionymus sacchari* (Cockerell), which occurs in Hawaii, is here left in this genus, although the circulus is markedly not of the type here considered to be characteristic of the genus. It may be held in the genus until further study on the basis of the presence of cerarii only on the anal lobes.

The grass-infesting species in general are the most puzzling of the Pseudococcidae. Many species are already known and there undoubtedly remain many more still to be found. Not until the group has been reviewed for the entire world will it be possible to give any clear statement of how the species may be arranged generically.

The following key is basically by Ferris, but I have added some notes to aid in the field recognition of the species.

Key to the Species of Trionymus Known to Occur in Hawaii

1. Circulus present, relatively very large and distinctly dumb-bell shaped; living female pinkish in body color, apparently ovoviviparous, but producing some cottony wax beneath body; usually on sugarcane............. **sacchari** (Cockerell).
   Circulus lacking 2
2. Anal lobe cerarii with three or more conical setae; living in rolled edges of leaves of *Eugenia sandwicensis* in the mountains .... **refertus** Ferris.
   Anal lobe cerarii with not more than two conical setae; on lilies and grasses.. 3
3. Dorsum of body with numerous tubular ducts, some of which are quite large and possess a distinct oral rim; three or more pairs of cerarii present on the terminal abdominal segments; living female purplish in body color, narrowed cephalad, oviparous, eggsac elongate; on lily bulbs.......
   .... **lounsburyi** Brain.
   Dorsum entirely without tubular ducts but with multilocular disc pores; cerarii present only on the anal lobes; living female pinkish in body color, oviparous, eggsac longer and broader than body; on bunch grass, Bermuda grass and other short grasses....................... **insularis** Ehrhorn.

Trionymus insularis Ehrhorn (fig. 139).
Trionymus insularis Ehrhorn, 1916:238, 244.

The insular mealybug.

Oahu, Molokai, Maui, Hawaii (type locality: Mauna Loa).

Immigrant. A similar species, if not this one, has been seen by Dr. Harold Morrison in material from Micronesia.

Hostplants: *Chaetochloa verticillata, Cynodon dactylon, Deschampsia australis, Eragrostis variabilis* (bunch grass), Hilo grass, *Panicum torridum,* silversword (*Argyroxiphium sandwicensis*) (this record may be erroneous).

Parasites: *Anagyrus nigricornis* Timberlake, *Anagyrus swezeyi* Timberlake, *Xanthoencyrtus apterus* Timberlake (Hymenoptera: Encyrtidae).

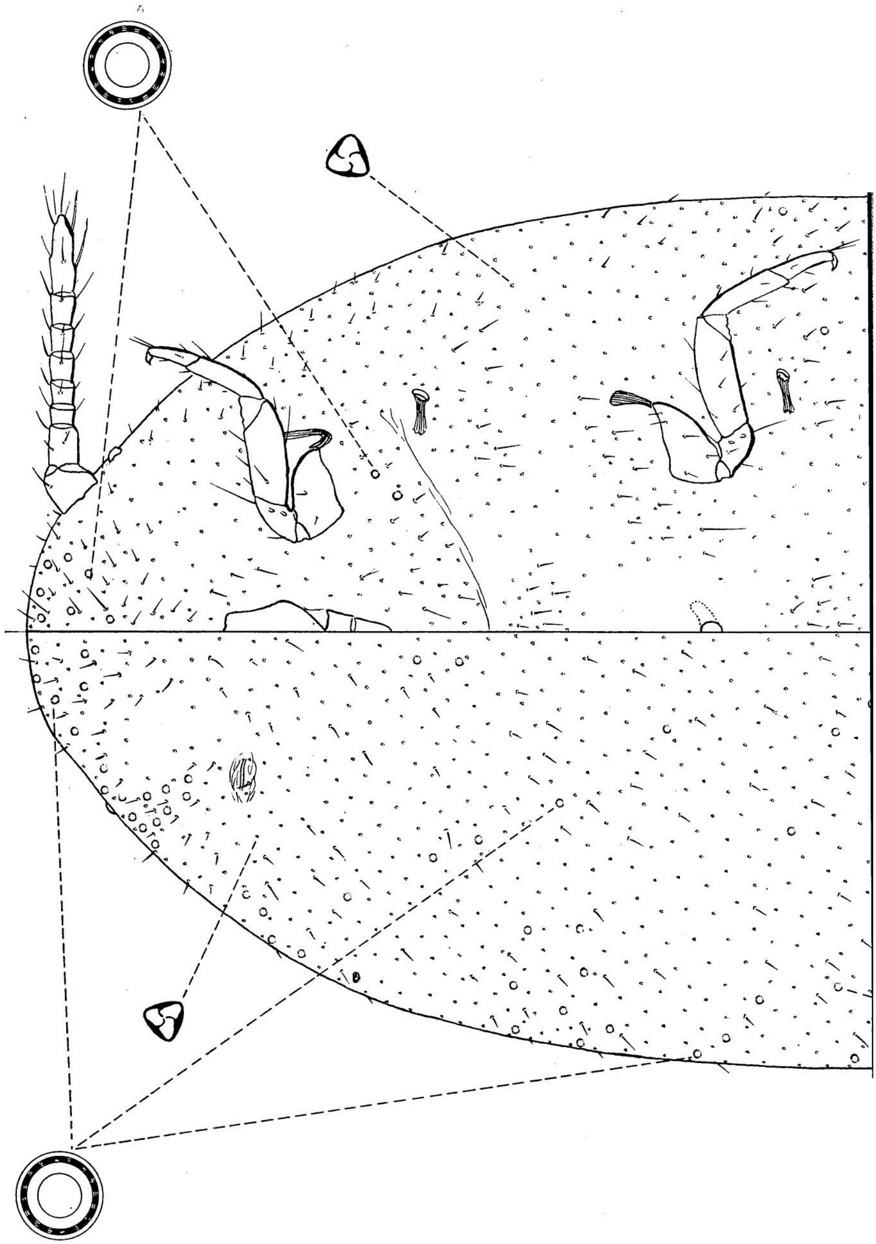
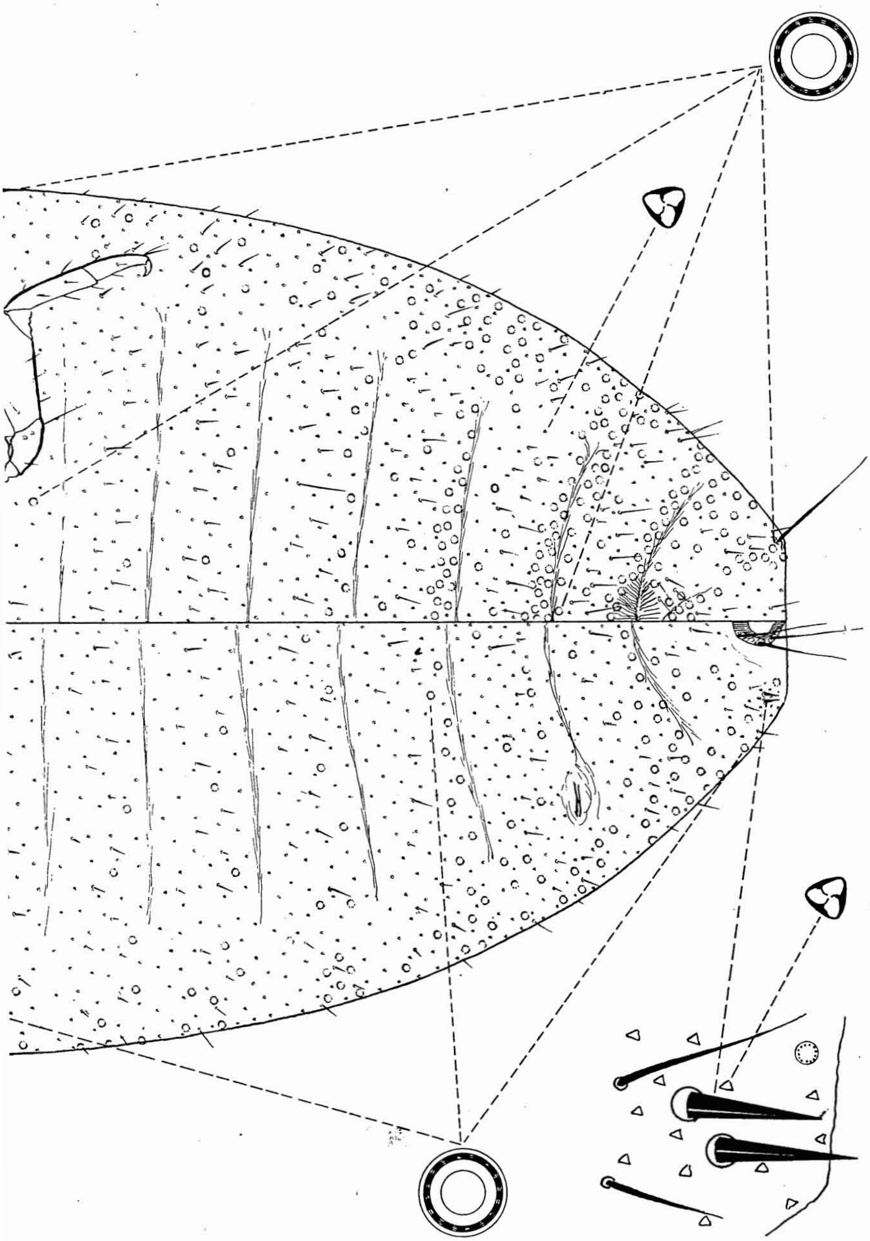


Figure 139—*Trionymus insularis* Ehrhorn, the insular mealybug. (Drawn by Ferris



Predators: *Cryptolaemus montrouzieri* Mulsant, *Scymnus debilis* LeConte, *Scymnus ocellatus* Sharp (Coleoptera: Coccinellidae); *Gitona perspicax* (Knab) (Diptera: Drosophilidae).

The adult females are pink in body color, are oviparous and produce an ovisac which, according to Ehrhorn (1916:244), is "longer and broader than adult, loosely woven." The species is found frequently in abundance on its various hosts.

Ferris adds the following notes:

The distinctive characters of this species, as compared with the others of the genus known from the Hawaiian Islands, are as follows: Cerarii present only on the anal lobes. Tubular ducts of any kind apparently entirely lacking, or if present at all extremely few and small. The exception is admitted because of the fact that in one specimen at hand one or two such ducts have been detected. Multilocular disc pores scattered about over the dorsum in small numbers, there being some even on the anterior margin of the head. On the venter they are confined for the most part to the abdominal region. Circulus lacking.

In the absence of any comprehensive study of this group for the entire world nothing can be said concerning the possibility that this species is known under some other name from other parts of the world.

The accompanying figures are based on specimens from *Eragrostis* sp., Halemanu, Kauai, T. H., O. H. Swezey, 1921. I have not seen the types and cannot verify the identification.

Trionymus lounsburyi Brain (fig. 140).

Trionymus lounsburyi Brain, 1912:179, figs. 2, 3; pl. 14, figs. 4–6; pl. 15; pl. 16, fig. 2.

The lily bulb mealybug.

Oahu.

Immigrant. Widespread; described from South Africa. First recorded from the Hawaiian Islands by Ehrhorn in 1916 (p. 237) from specimens collected in Honolulu.

Hostplants: *Amaryllis, Crinum, Zephyranthes.*

Parasites: Timberlake reared the encyrtid wasp *Anagyrus nigricornis* Timberlake from females under experimental conditions.

Few records exist in our literature regarding this species. A colony which I found near the base of a leaf of *Amaryllis* in my garden was attended by *Pheidole* ants, which had concealed the mealybugs with a covering of soil and debris. The scales appear gray to the naked eye, but when mashed the body contents are brownish-orange or purplish-brown. They are elongate oval in shape (mature examples 1.0 $\times$ 2.5 mm. to 1.3 $\times$ 3.0 mm.) Around the anus there are four stout caudal wax processes in addition to a short median process. The two outer processes are usually smaller than the inner pair, which may be three-fourths as long as the breadth of the body. There are no lateral filaments. Long, fine, wire-like,

glassy wax filaments are produced from the dorsum and sides, and these are gathered together to form a mass in which the more or less brownish-orange or reddish eggs are suspended (eggs 0.15 × 0.35 mm.).

Ferris appends the following information:

This species is readily separable from the others of the genus known from Hawaii by the following characters: Cerarii present on the last three abdominal segments and at times on the fourth, represented sometimes by a single conical seta on the fourth. Dorsum of entire body and marginal areas of abdomen and thorax with scattered, quite large, tubular ducts, each with a distinct oral rim. Dorsum and venter of abdomen and marginal regions even of head with numerous, very small tubular ducts, these without an oral rim or a distinct collar and very short, being scarcely twice as long as wide. Multilocular disc pores confined to venter of abdomen. Circulus lacking.

No information is available as to the basis of the identification of this species with *Trionymus lounsburyi* Brain. The species is not recognizable from Brain's description and the identification remains to be authenticated.

Specimens from undetermined bulbs at Los Angeles, California, agree very closely with those upon which the accompanying illustrations were based, these being from *Amaryllis,* Manoa Valley, Honolulu, Ehrhorn, collector and determiner.

Trionymus refertus Ferris, new species (fig. 141).

Type host and locality: From *Eugenia sandwicensis,* on Konahuanui, Oahu, T. H., August, 1945, collected by Kay Sakimura.

Recognition characters: Length of largest specimen (on slide) 2.4 mm. Body slender and elongate. Antennae eight-segmented. Circulus lacking. Only two pairs of cerarii present, these on last two abdominal segments. Anal lobe cerarius with four, or at times five, short, conical setae and several slender hairs, which are accompanied by a quite large cluster of trilocular pores. Penultimate cerarius with one conical and one slender seta and only three or four pores. Multilocular disc pores entirely lacking. Tubular ducts small and short, being only about twice as long as wide and each with a distinct collar, very few, occurring on both dorsal and ventral sides of body, those on dorsal side confined to from one to three on each half of body on thoracic and first three or four abdominal segments, those on ventral side appearing in very small numbers about vulva and in midregion of abdominal segments, with usually one in lateral area of each abdominal segment and very few in lateral areas of meta- and mesothorax. Setae, both dorsally and ventrally, few, slender.

Notes: The presence normally of four conical setae in each anal lobe cerarius, the complete absence of multilocular pores and the very few and small tubular ducts separate this species nicely from anything else at present referred to this genus. Although *Trionymus* is composed for the most part of grass-infesting forms there seems to be no reason to exclude this species from the genus. The specific name refers to the crowded pores and setae of the anal lobe cerarii.

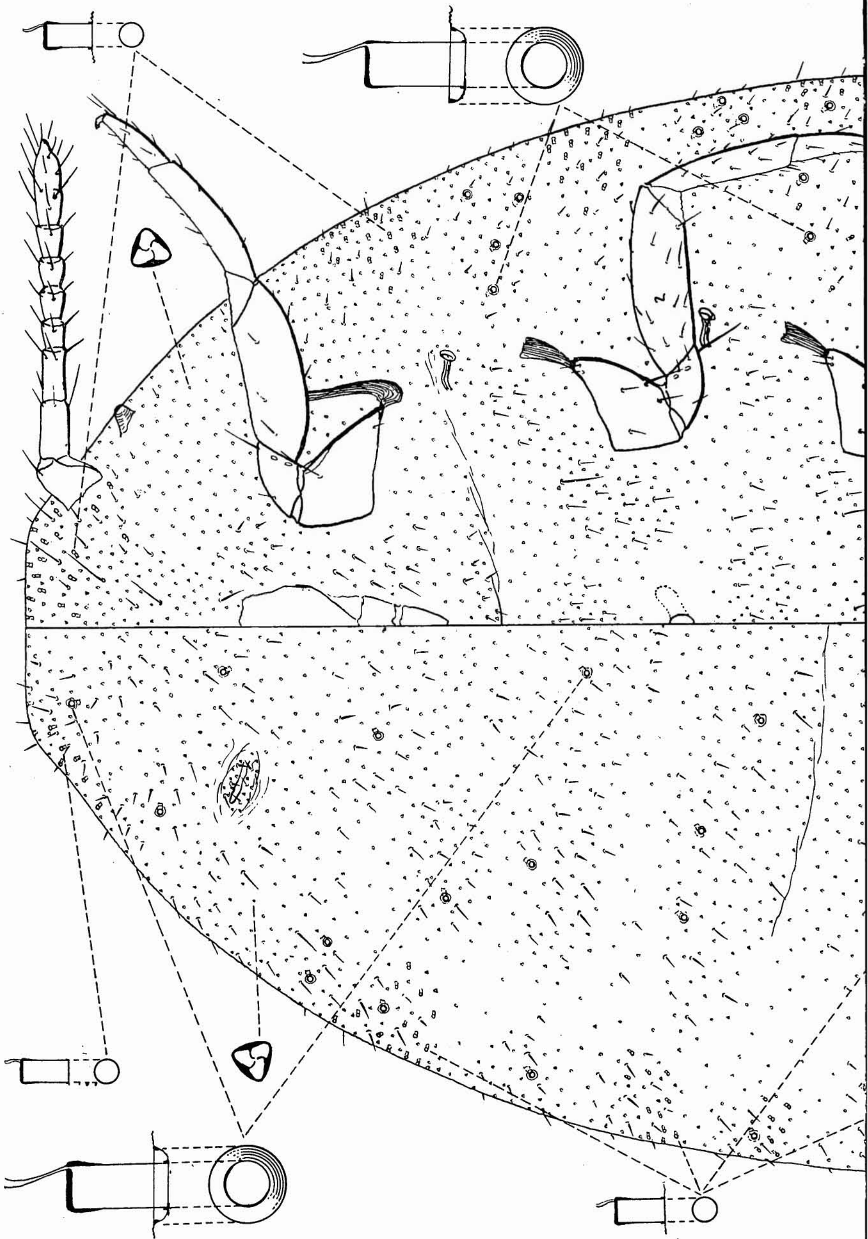
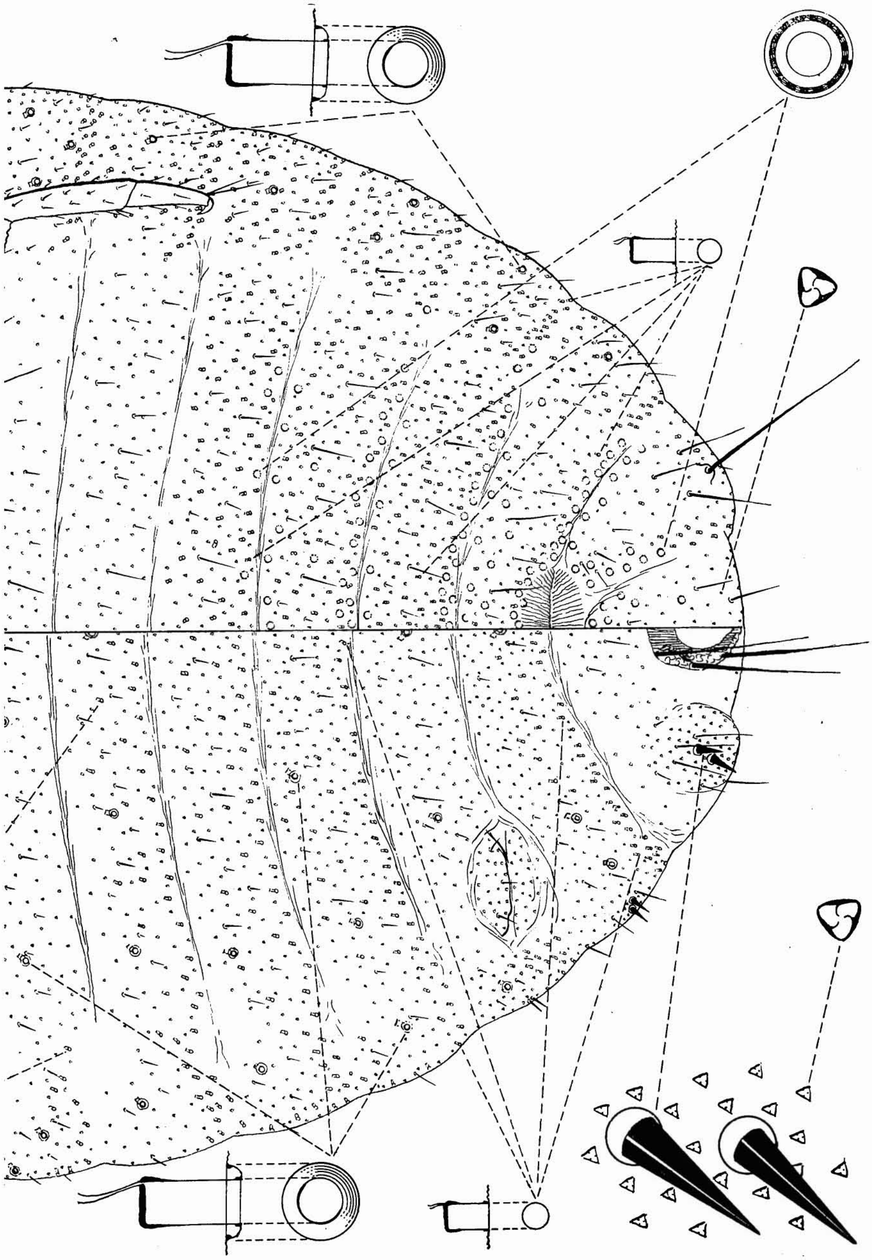


Figure 140—*Trionymus lounsburyi* Brain, the lily bulb mealybug. (Drawn by Ferr



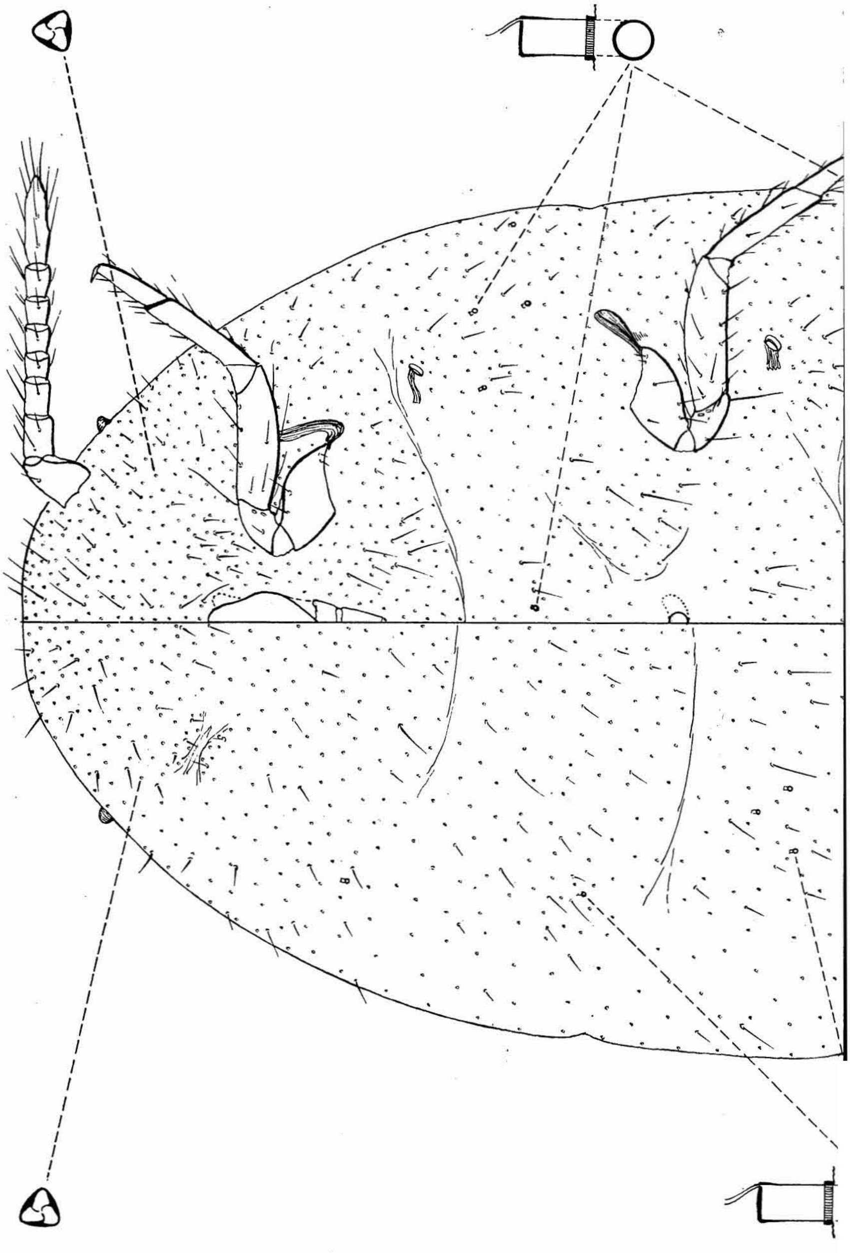
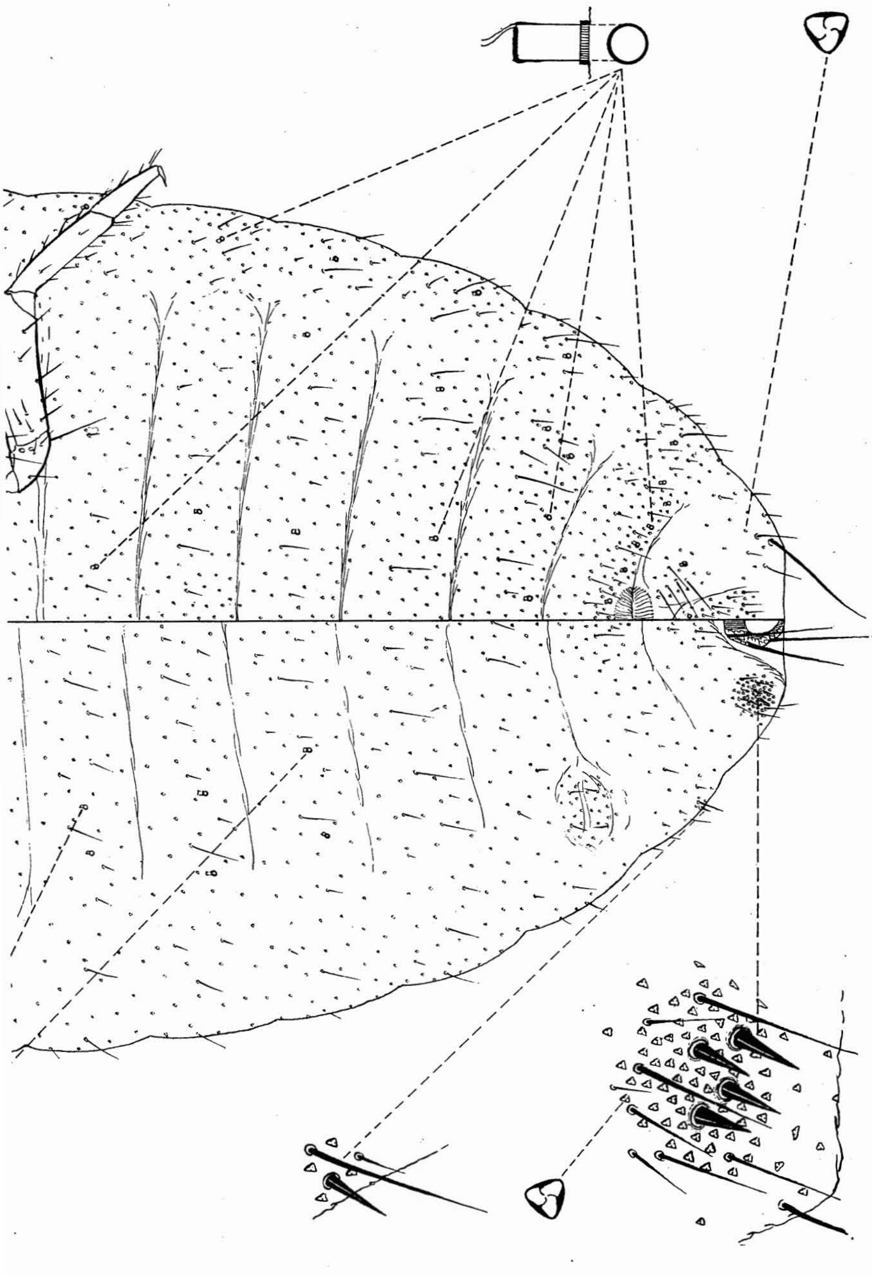


Figure 141—*Trionymus refertus* Ferris, new species. (Drawn by Ferris.)



The type slide is in the Bishop Museum.

This species causes the edges of the leaves of its hostplant to curl in tight rolls which form tubes in which small colonies of the insect live. A living female measured 0.75 × 1.75 mm. in breadth and length. It was sub-parallel-sided, thinly clothed with white meal, yellowish-gray in body color, paler in middle and ovoviviparous. (E.C.Z.)

Trionymus sacchari (Cockerell) (figs. 142, 143).

Dactylopius sacchari Cockerell, Jour. Trinidad Field Naturalist's Club, 2:195, 1895 (I have been unable to consult this reference).

Pseudococcus sacchari (Cockerell), of various authors. Morrison, 1920:171, 173, fig. 15.

The pink sugarcane mealybug.

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. A species found widespread on sugarcane. Koebele (1896:596) evidently was the first entomologist to record the presence of this species in Hawaii.

Hostplants: *Holcus halepensis* (Johnson grass), sorghum, sugarcane.

Parasites: *Anagyrus saccharicola* Timberlake (Hymenoptera: Encyrtidae).

Fungi: *Aspergillus parasitiosus* Speare, *Entomophthora pseudococci* Speare.

Predators: *Cryptolaemus montrouzieri* Mulsant, *Scymnus debilis* LeConte (Coleoptera: Coccinellidae); *Gitona perspicax* (Knab) (Diptera: Drosophilidae).

This pinkish species can be distinguished easily from the other mealybugs found on sugarcane because it lacks the lateral and caudal wax filaments characteristic of the others. It is a large, plump species which may reach a length of 5 mm.

Swezey has made the most extensive local study of the species, and the following details are quoted from his work (1913:201):

During the egg-laying period the females are surrounded by numerous young of such small size as to give the impression that they are producing their young viviparously. Careful observations, however, show that the eggs are laid in an advanced stage of development, and that they hatch in a few minutes after leaving the female. Egg laying goes on continuously for several days. The intervals of time between successive eggs is such that the previously laid ones are mostly hatched before the laying of others, so that there may not be more than one or two unhatched eggs present beneath a female at any one time. The freshly hatched young remain beneath the female for a time before crawling away to locate near her, and this feature easily leads to the idea that the young are produced already hatched. Only by close observation will it be seen that eggs are laid and hatch in a few minutes thereafter. Observations on one female showed that she laid an egg at intervals of about 12 minutes, and the time of hatching of these varied from 15 minutes to half an hour.

More than 1,100 eggs were laid by one female over a 21-day period.

This species maintains itself as a common sugarcane insect, but it is not considered a serious pest of cane in Hawaii. It appears that it protects itself well from ladybird beetles by its secretive habits, for it occurs most abundantly beneath the tight leaf sheaths and may also be found on underground parts of the plants. However, the introduced coccinellid *Cryptolaemus montrouzieri* Mulsant has aided

greatly in its control. Koebele in 1896 (p. 596) said, "It had done considerable damage to the cane by sucking the sap and making the stripping a hard task, owing to the copious dust produced by the powdery exudation of the insect. To all appearance, during the present season, the scale has practically disappeared from the plantations visited, this owing to the work of an introduced ladybird, *Cryptolaemus Montrouzieri,* which feeds chiefly on the mealy bugs."

It is the belief of the present entomological staff of the H.S.P.A. Experiment Station that the satisfactory field control of the pink mealybug of sugarcane in Hawaii should be credited more to *Anagyrus saccharicola* than to *Cryptolaemus.* This control is one of the most striking, if less known, successes achieved by biological means in these islands. Before the introduction of *Anagyrus* from the Philippines by Hadden in 1930, the pink mealybug was omnipresent on sugarcane throughout the Territory. Hardly a stalk of plant or ratoon cane in the field could be stripped of leaves without disclosing large colonies of *T. sacchari.* Within about two or three years after the establishment of *Anagyrus,* the mealybug was everywhere so reduced in numbers that only small groups of living *Trionymus* were usual beneath leaf sheaths, and mummified (parasitized) mealybugs were readily found wherever colonies persisted or had been present; this condition continues to the present day.

The following notes are by Ferris: This species should not be confused with *Ripersia sacchari* Green, which is quite different. It is readily recognizable by the following characters:

At maturity a very rotund form. Cerarii confined to anal lobes, where each is represented by a pair of small, rather slender conical setae. Circulus present, of very distinctive form, being relatively large and noticeably dumb-bell shaped. Margins of three abdominal segments anterior to last, each with a large seta as long as that of anal lobes the presence of which is indicated by large sockets, even if setae are broken off. Dorsum apparently entirely without tubular ducts, and venter of abdomen with very few and these extremely minute. Multilocular disc pores abundant on ventral side of abdomen and in clusters near spiracles and present even to the head; likewise present on dorsum of abdomen. Antennae short, seven-segmented.

In the opinion here held, *sacchari* (Cockerell) does not belong to *Trionymus,* but it may better be left here than in *Pseudococcus* until comprehensive studies have shown a better assignment for it.

The accompanying figures are based upon specimens from sugarcane, Oshima, Kagoshima Ken, Japan.

Genus **FERRISIANA** Takahashi, 1929

Ferrisia Fullaway, 1923:311.

Genotype: *Dactylopius virgatus* Cockerell.

Pseudococcidae with no tooth on the claw; with eight-segmented antennae: with

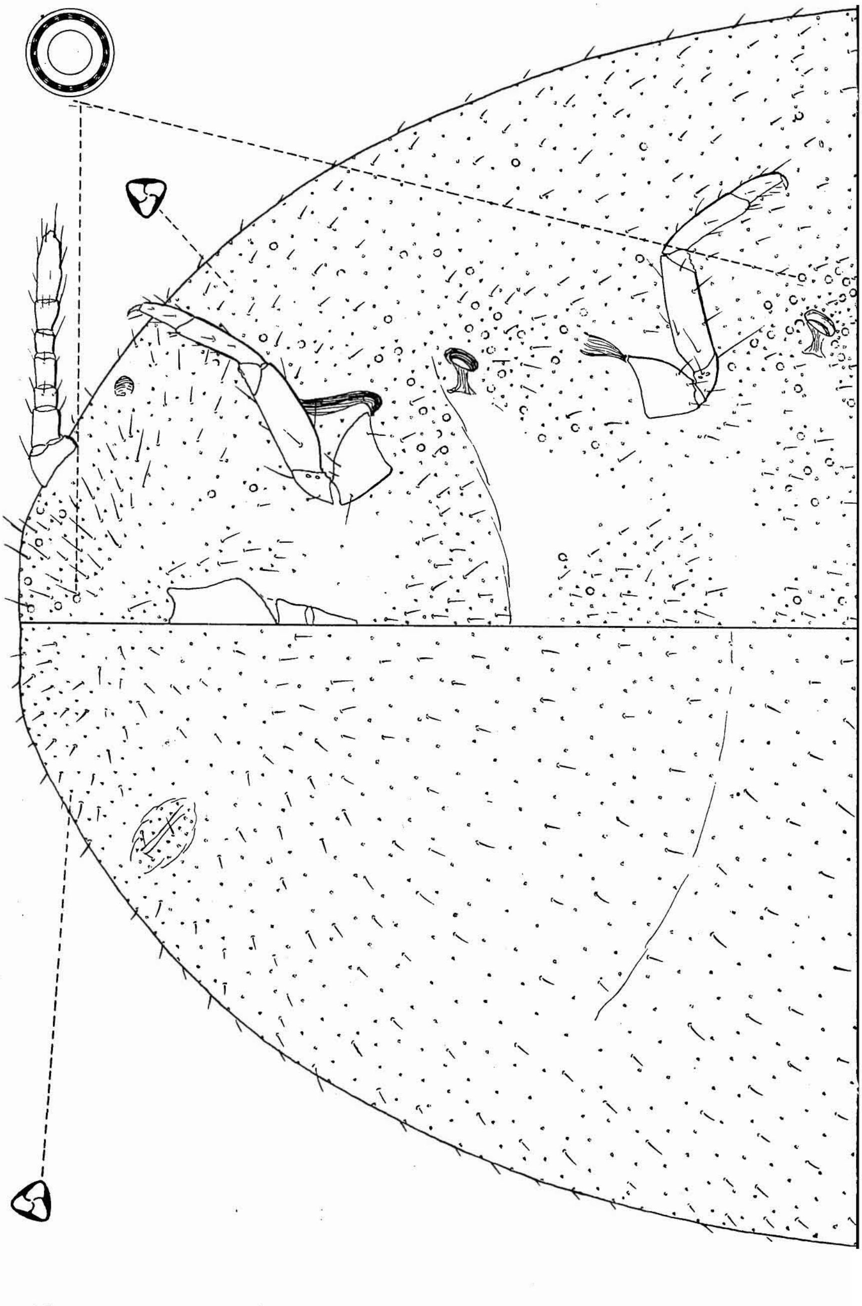
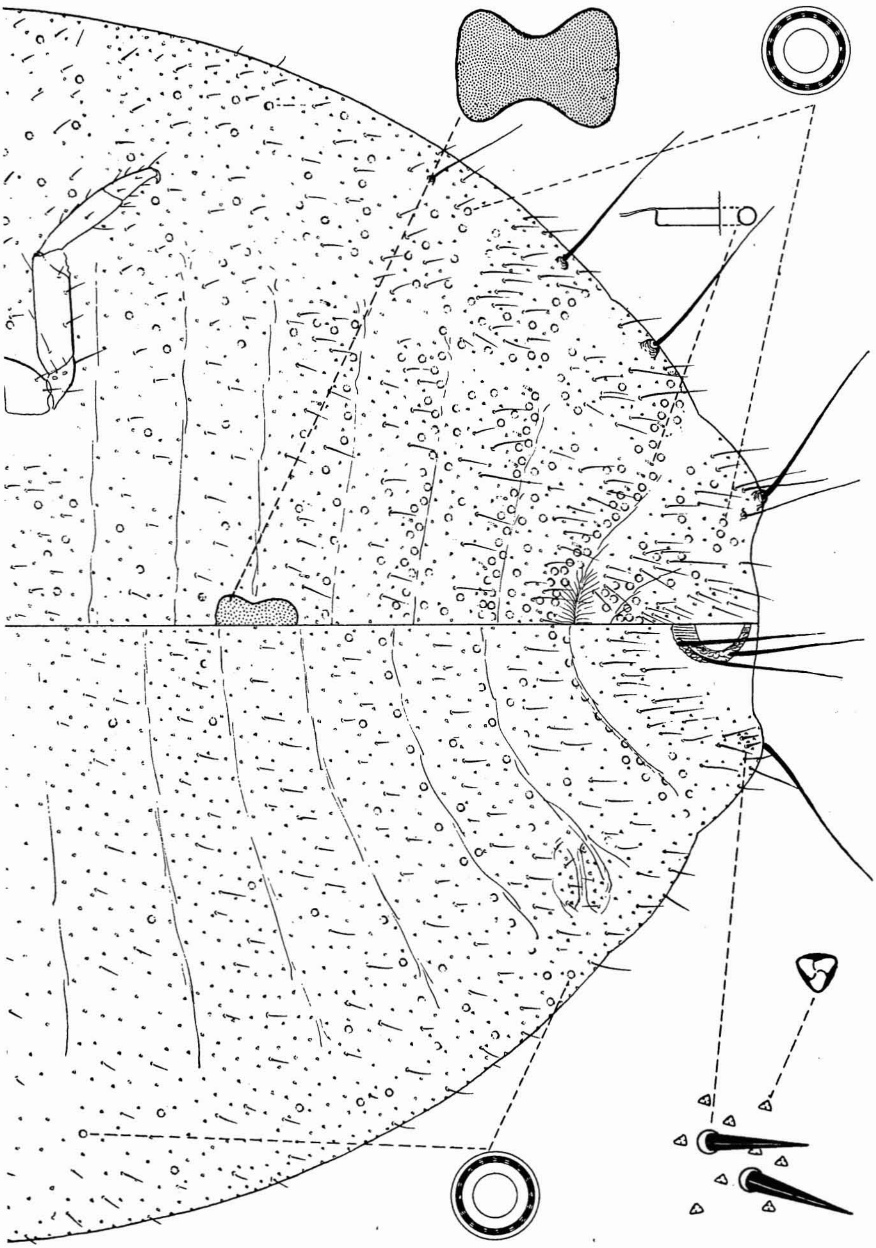


Figure 142—*Trionymus sacchari* (Cockerell), the pink sugarcane mealybug. (Drawn by Ferris.



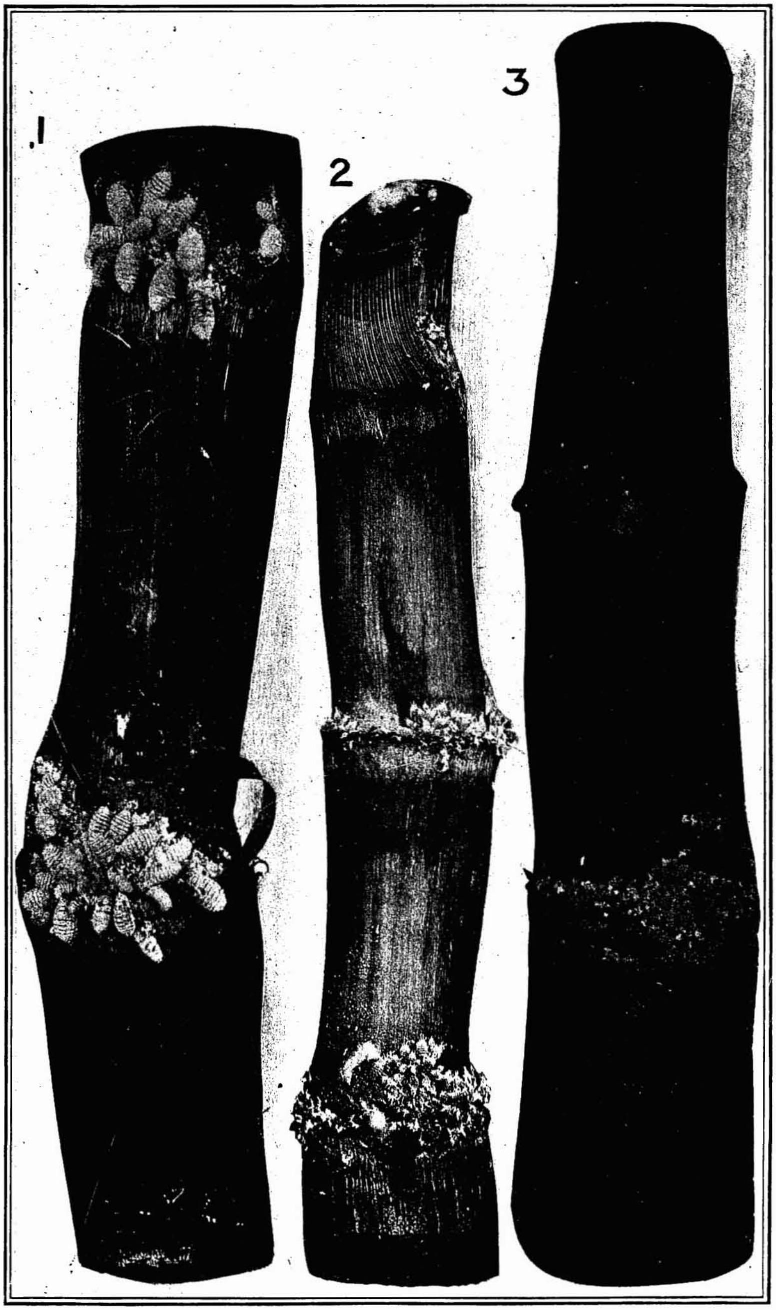


Figure 143—Some mealybugs on sugarcane. 1, *Trionymus sacchari* (Cockerell), the pink sugarcane mealybug; 2, *Pseudococcus boninis* (Kuwana), the gray sugarcane mealybug; 3, *Pseudococcus brevipes* (Cockerell), the pineapple mealybug. (After Swezey, 1913.)

but one pair of cerarii, these on anal lobes; dorsum with extremely large tubular ducts, each of which has orifice surrounded by a sclerotized area that normally bears one or more small setae; circulus large and crossing intersegmental line between two segments.

At present but one species is referred to this genus, but there are others that belong to it. It has nothing to do with *Trionymus* and certainly should be separated from *Pseudococcus*.

There is a little nomenclatorial problem associated with it. It was first separated from *Pseudococcus* as *Ferrisia* by Fullaway in 1923. In 1929 it was renamed *Ferrisiana* by Takahashi, apparently because of the prior existence of a generic name, *Ferrissia* Walker, 1903. Whether or not *Ferrisia* is preoccupied by *Ferrissia* [note the double "s," E.C.Z.] is a neat little legalistic point over which we need not linger. The point might as well be conceded. (Ferris.)

Ferrisiana virgata (Cockerell) (fig. 144).
Dactylopius virgatus Cockerell, 1893:178.
Dactylopius ceriferus Newstead, Koebele, in error, 1898:106.
Pseudococcus virgatus (Cockerell), Ferris, 1919:297, fig. 17.
Ferrisia virgatus (Cockerell) Fullaway, 1923:311.
Ferrisiana virgata (Cockerell) Takahashi, 1929:429.

The striped mealybug.

Kauai, Oahu, Molokai, Maui, Hawaii, French Frigate Shoal.

Immigrant. A widely spread species, described from Jamaica. First recorded from the Hawaiian Islands by Koebele in 1898 (p. 106) (the species was wrongly identified for him by Maskell in 1897), but there is good reason to believe that the scale was widespread in the islands long before this record.

Hostplants: *Acacia farnesiana, Acalypha, Alocasia, Cassia gaudichaudii,* cotton, croton, *Dolichos lablab, Erythrina,* garden bean, guava, *Hibiscus,* litchi, monkeypod, oleander, poinsettia, *Portulaca oleracea, Solandra grandiflora* (cup of gold), taro, velvet bean, *Viola.*

Parasites: *Bothriencyrtus insularis* (Cameron) (*Blepyrus*), *Aenasius advena* Compere, *Protaenasius* sp., *Leptomastidea abnormis* (Girault) (Hymenoptera: Encyrtidae).

Predators: *Cryptolaemus montrouzieri* Mulsant, *Olla abdominalis* (Say), *Azya luteipes* Mulsant (Coleoptera: Coccinellidae); *Allograpta obliqua* (Say) (Diptera: Syrphidae).

These enemies of the mealybug have played a remarkable role in controlling this species, which at one time was a very common pest in Hawaii. It is now rather uncommon.

Ferris characterized the species as follows (1919:297–298):

A rather slender form, attaining a length of 4.5 mm. Thinly dusted with powdery secretion, with a pair of longitudinal submedian dark stripes. Caudal tassels attaining about half the

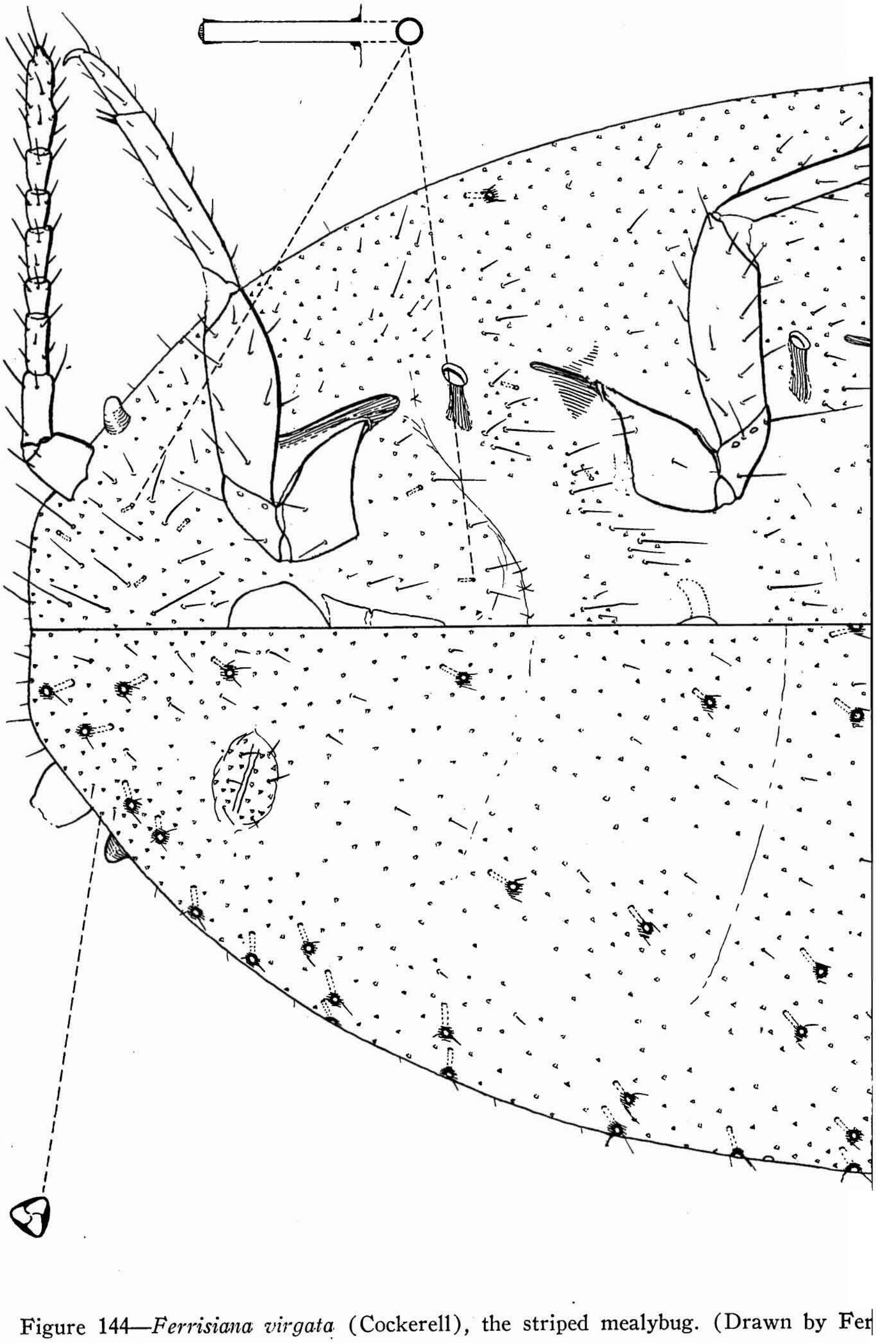
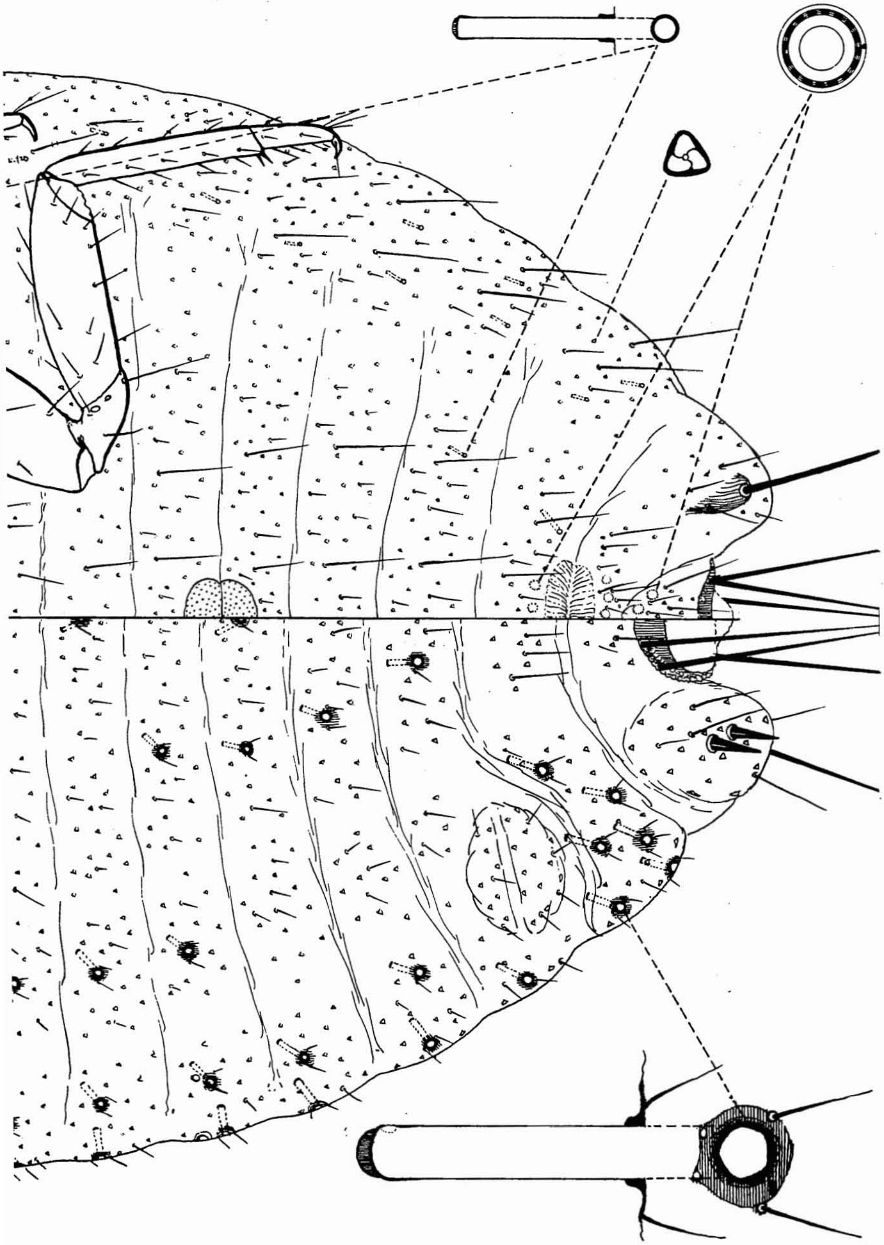


Figure 144—*Ferrisiana virgata* (Cockerell), the striped mealybug. (Drawn by Fer



length of the body, lateral tassels lacking. Dorsum bearing numerous delicate, glassy, waxen threads which arise from near the margins.... The most conspicuous feature of the species is the presence of numerous, unusually large ducts, the mouths of which are surrounded by a small, chitinized area which bears from one to four small setae. It is from these ducts that the glassy threads, which are so conspicuous in the living insect, arise.... Except for a median pair on three or four abdominal segments and an occasional duct on the dorsum of the thorax they are confined to the lateral margins, there being normally six or seven at each lateral margin of the penultimate segment and two or three at each lateral margin of the other abdominal segments (except the last) and the thoracic segments also, together with an indefinite number on the head.

It is possible that there are two very similar species included under this name, but the question is at present unexplored. Setting aside this possibility, the species is immediately recognizable by the combination of characters given for the genus. The huge ducts, which are responsible for the glassy threads of wax that appear in the living insect, combined with the presence of but a single cerarius, are distinctive. There exist certain species, commonly placed in *Phenacoccus,* in which such huge ducts are present, but in these species there is a tooth on the claw and there are numerous cerarii. (Ferris.)

Several hundred oval, golden-yellow eggs may be deposited by a single female, and they hatch in a day or two. The first-stage larvae have six-segmented antennae and molt in about 20 days to second-instar forms which have seven-segmented antennae. These in turn transform to adults in about eight days. The male pupal stage lasts six days. About two months are required for a complete life cycle. (From Fullaway, 1909:11–12.)

Genus **NESOCOCCUS** Ehrhorn, 1916:238

Adult females with dense, fine, dorsal, glassy, hair-like vestiture; antennae six- or, normally, seven-segmented; legs well developed, femora stout; entire derm with unusually large and conspicuous round pores which form outstanding clusters toward the sides of each segment; anal ring and caudal lobes *Pseudococcus*-like, the latter not strongly protuberant, setiferous.

This is a peculiar genus not known outside of the Hawaiian Islands. I recently (1945) sent some fresh material to Dr. Harold Morrison for study and for his opinion in regard to its status. He generously answered my plea with the following paragraph of notes and the excellent plate of the genotype.

In the present state of our knowledge of generic units among the mealybugs, only a tentative basis can be given for the separation of *Nesococcus* from other genera in the group. The body shape, antennae, back and legs, except for an obvious stoutness of the last, do not appear to depart from the characteristic pattern of the group. If the striking features are ignored for the moment, the genotype on the basis of the 6–7 segmented antennae, non-denticulate claws and cerariian development limited to the single anal lobe pair, appears to approach rather closely the genus *Trionymus* as this has been defined in recent years, but it differs strikingly

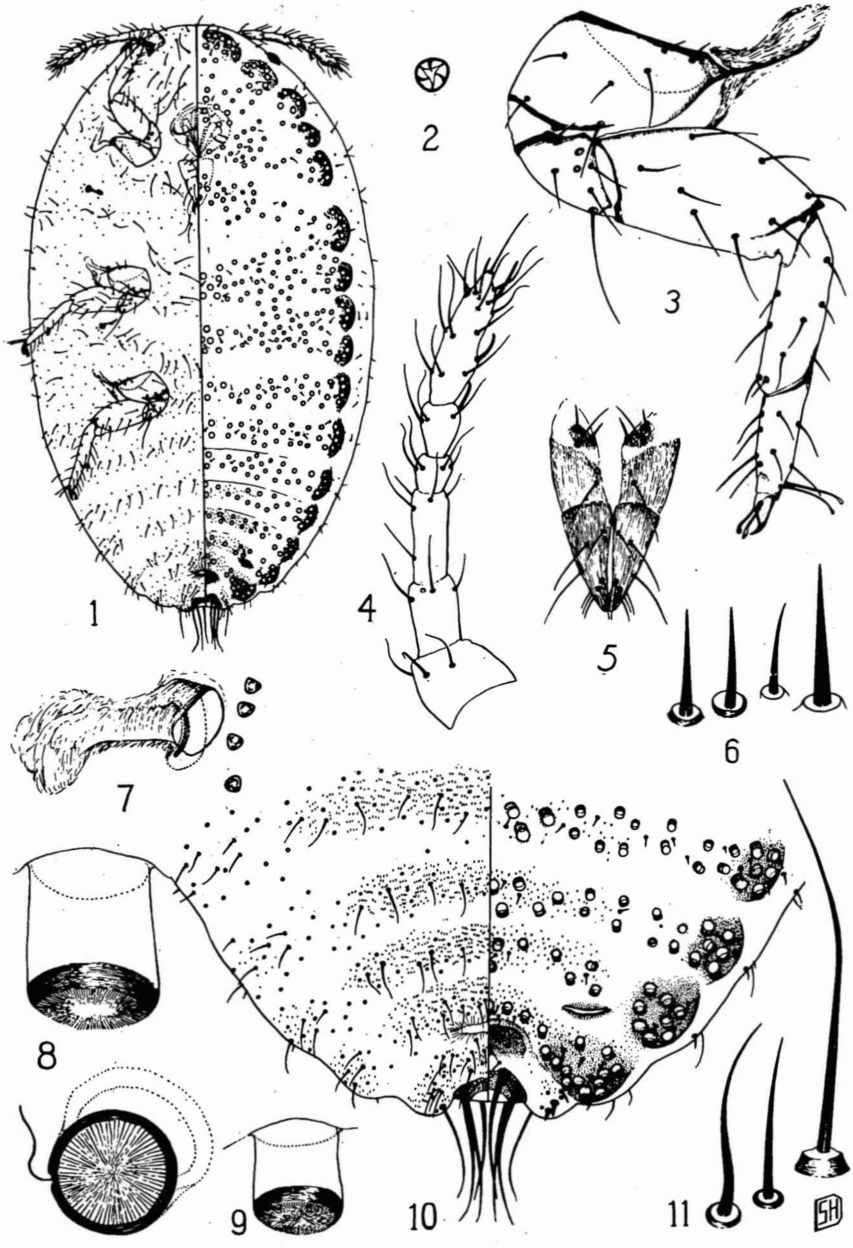


Figure 145—*Nesococcus pipturi* Ehrhorn. **1**, adult female, dorsal and ventral; **2**, trilocular pore from ventral surface; **3**, posterior leg; **4**, antenna; **5**, rostrum; **6**, dorsal body setae; **7**, posterior spiracle; **8**, large tubular duct from side and inner end; **9**, same from intermediate area; **10**, apex of abdomen, dorsal and ventral; **11**, ventral setae. (Drawing by Mrs. Sara Hoke Debord, and made under the direction of Harold Morrison, U. S. Bureau of Entomology and Plant Quarantine.)

from typical members of this genus through the possession of the numerous, clustered, large, short tubular ducts which crowd the dorsal surface, through the presence of a large, swollen median sclerotized area, just anterior to the anal ring, and somewhat suggesting the cauda found in some other insects, through the absence of multilocular disk pores and small tubular ducts, and through the absence of a ventral cicatrix. These last, negative, characters are, of course, shared by some other species now placed in *Trionymus,* but I know no other mealybug exhibiting anything approaching the first two characters mentioned.

Nesococcus pipturi Ehrhorn (fig. 145).
Nesococcus pipturi Ehrhorn, 1916:238, 246. Genotype.

Endemic. Oahu (type locality: Mount Tantalus), Molokai.
Hostplant: *Pipturus albidus* ("mamake").
This is an unusual mealybug. It lives in the mountains on the leaves of "mamake" and is usually found near the midribs. Many of the specimens I have collected have been heavily parasitized by Hymenoptera, but I do not know the identity of the parasites.

Family **ASTEROLECANIIDAE** (Berlese, 1898) Enderlein, 1920

Only one genus of this widespread family is known to occur in our area. As represented by *Asterolecanium,* the family may be recognized here by the following assemblage of characters: adult female immobile, enclosed in a glassy or horny, shell-like, fringed ovisac, legs and antennae rudimentary; body sac-like and without evident segmentation; with numerous 8-shaped dermal gland pores arranged in rows especially around the body margins; some species causing a pitting or roughening of the bark of the hostplant.

Subfamily ASTEROLECANIINAE

Genus **ASTEROLECANIUM** Targioni-Tozzetti, 1868

A comprehensive survey of this genus has been published by Miss Louise Russell (1941). Because she has handled probably more material of the genus than any other worker, I have considered it worth while to quote her diagnoses of the females.

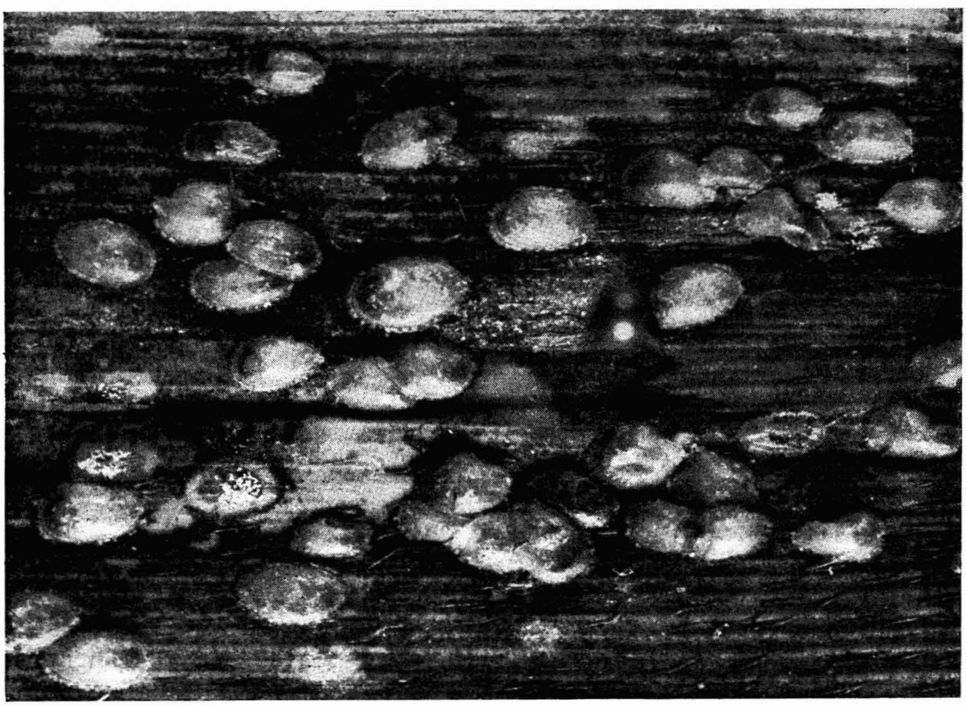


Figure 146—*Asterolecanium bambusae* (Boisduval), the soft bamboo scale.

Key to the Species of Asterolecanium Known in Hawaii

1. Anal ring with only two small setae; entire apex of abdomen heavily sclerotized; on bamboo........**scirrosis** Russell.
   Anal ring with six setae; apex of abdomen not so sclerotized 2
2(1). Apex of abdomen with six pairs of setae; dorsal tubes absent; on various plants, but not on bamboo, and frequently causing a pitting and roughening of the bark of the host......................**pustulans** (Cockerell).
   Apex of abdomen with five pairs of setae; dorsal tubes present (a pair of tube-like structures situated on dorsum between vulva and anal ring).................... 3
3(2). Venter with many multilocular or quinquelocular pores near vulva........................**bambusae** (Boisduval).
   Venter without such pores......**miliaris miliaris** (Boisduval).

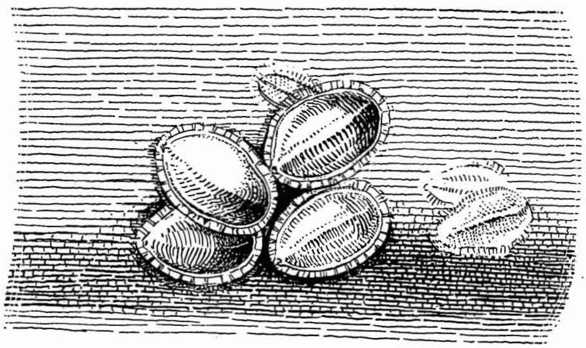


Figure 147—*Asterolecanium bambusae* (Boisduval), the soft bamboo scale. (Abernathy drawing.)

Asterolecanium bambusae (Boisduval) (figs. 146, 147).
Chermes bambusae Boisduval, 1869:261.
Russell, 1941:47, figs. 6, J–O; 7, A–G; pl. 2, F, G.

The soft bamboo scale.

Oahu, Hawaii.

Immigrant. An Oriental species which is now widely spread over the world. First listed from Hawaii by Kotinsky, 1910:127.

Hostplant: bamboo; on stems and both leaf surfaces.

Russell (1941:47) described the shell of the adult female as follows:

Usually distinctly longer than wide, somewhat ovoid, posterior end slightly produced and often upturned; 1.5–3.5 mm. long, 1–2.5 mm. wide; slightly to rather strongly convex dorsally, sometimes with a faint longitudinal median carina near posterior end, flat ventrally; greenish, brownish, or pale yellow, transparent, thin, shiny; marginal and dorsal filaments whitish to pale pinkish, a few of the latter along median line, and sometimes in submedian, lateral, or submarginal area; larval exit narrow elliptical, in margin.

This species is a pest of bamboo in some places.

Asterolecanium miliaris miliaris (Boisduval) (fig. 148).
Chermes miliaris Boisduval, 1869:261.
Russell, 1941:129, figs. 41, B–G; pl. 5, E.

Kauai, Oahu.

Immigrant. An Oriental species which is now nearly tropicopolitan. First recorded from the Hawaiian Islands by Kotinsky (1910:127) from specimens collected at Lihue, Kauai, by Van Dine.

Hostplant: bamboo; on stems and both leaf surfaces.

[The tiny test of the female is] Longer than wide but differing in proportions of length to width, anterior end rounded, sides often parallel, posterior end slightly narrowed and produced; 1–1.6 mm. long, 0.4–0.9 wide; nearly flat to very slightly convex dorsally, usually with a faint longitudinal median carina and sometimes with very faint transverse striations; flat ventrally; greenish, brownish, or clear pale yellow, transparent, thin, shiny, slightly punctate; marginal filaments whitish to pale pinkish; circular larval exit in ventral surface at margin. (Russell, 1941:129.)

This species has proved to be a pest of bamboo in some places, but we have not seen it often here.

Figure 148—*Asterolecanium miliaris* (Boisduval).

Asterolecanium pustulans (Cockerell) (fig. 149).
Asterodiaspis pustulans Cockerell, Jour. Institute Jamaica 1:143, 1892 (I have not seen this reference).

The pit scale.

Oahu, Molokai.

Figure 149—*Asterolecanium pustulans* (Cockerell), the pit scale.

Immigrant. A nearly cosmopolitan species. First listed from Hawaii by Craw in 1896 (p. 40) (quarantine interception at San Francisco).

Hostplants: avocado, fig, *Grevillea robusta, Hibiscus, Jasminum sambac, Lantana,* mango, oleander, *Passiflora vitifolia, Prosopis* (algaroba), "red lova lova," *Sapium* (Chinese tallow) and other plants not yet recorded as infested in Hawaii.

Parasite: *Tomocera californica* Howard (Hymenoptera: Miscogasteridae).

[Female test] Practically circular to ovoid, posterior end sometimes slightly produced; 1–1.85 mm. in diameter, or 1.25–2 mm. long and 1–1.65 mm. wide; nearly flat to fairly convex dorsally, usually with a faint longitudinal median carina and faint transverse striations; flat to convex ventrally; brownish or greenish yellow, transparent, punctate; marginal and dorsal filaments whitish to pinkish, some dorsal filaments longer and others shorter than marginal ones; elliptical larval exit in margin. (Russell, 1941:165.)

This species may heavily infest its hosts, and may produce on some a characteristic pitting and roughening of the surface. The pits, if produced, may range from shallow depressions to such deep depressions that the host tissues tend to grow over and enclose the scales. The scale is not uncommonly found damaging fig trees in Hawaii. It may so weaken the twigs and small branches that they fall victim to heavy infestations of scolytid beetles.

Asterolecanium scirrosis Russell.

Asterolecanium scirrosis Russell, 1941:184, fig. 62, E–L; pl. 8, M.

Oahu.

Immigrant. This Oriental species has not been recorded from Hawaii heretofore, but some bamboo material collected in Honolulu in 1918 was found infested

with this species, plus *Antonina bambusae, Asterolecanium bambusae* and *Phenacaspis sandwicensis,* by Morrison, who kindly examined the specimens for me.

Hostplant: bamboo.

Russell's (1941:184) description of the female test is as follows:

> Dorsal and ventral surfaces flat at anterior end if pressed tightly between leaf and stem, with 1 or 2 ridges formed around flattened area, the entire test in this case broadly wedge-shaped; if resting rather loosely on the petiole of the leaf, both surfaces fairly convex and the test roughly ovate or nearly round, in any case the posterior end exposed, rounded and slightly produced; a distinct margin seldom clearly indicated; 0.75–0.95 mm. long, 0.55–0.75 wide; brownish or greenish yellow, nearly opaque, punctate, varying from very rough and irregular to comparatively smooth; marginal and dorsal filaments not observed; elliptical larval exit in produced area.

Miss Russell also notes the peculiar habit of the species as "Living at the point of articulation of the blade and sheath of the leaf, the anterior end of the test either pressed tightly between the leaf and stem or resting rather loosely on the leaf petiole, the ventral surface of the test against the upper surface of the leaf, the dorsal surface against the stem."

Family **KERMIDAE** Ferris, 1937:5

Our representatives of this group somewhat resemble certain mealybug-like scales, for they are enclosed in a felt-like mass of white waxy exudation. This character, however, is not found in all genera of the family. According to Ferris (1937:5) the diagnostic characters of the group are as follows:

it does not possess abdominal spiracles, brachial plates, dorsal ostioles, an anal operculum, a pygidium, or ordinarily the 8-shaped pores which are characteristic of other groups. The anal ring is normally setigerous and cellular, but is at times vestigial. The anal lobes are frequently heavily sclerotized and prominent, but are at times obsolete. The one really positive distinguishing character is to be found in the form of the tubular ducts, these being reflexed at their inner extremity to form a deep cup, from the rim of which rises a filamentous prolongation.

A single genus in our adventive fauna is assigned here.

Genus **ERIOCOCCUS** Targioni-Tozzetti, 1868

This is a large, nearly cosmopolitan genus and is evidently the largest coccid genus inhabiting Australia. Professor Ferris has prepared the following notes and key:

Coccoidea referable to the family Kermidae, that is: without abdominal spiracles; without brachia or brachial plates; without a pair of plates forming an operculum over anus; without dorsal ostioles; with terminal segments of abdomen not fused into a pygidial plate; anal ring usually present, more or less cellular and bearing setae; tubular ducts of a distinctive type, having inner end somewhat expanded and with its walls reflexed to form a cup from rim of which rises a delicate, filamentous prolongation. Separable from other members of family by the following characters: antennae and legs remaining at maturity and well developed; derm remaining membranous at maturity; anal ring present, fully developed and setigerous; anal lobes well developed; at maturity enclosed within a felted sac.

Notes: This is a very large genus, there being perhaps a hundred known species which belong to it. Its members are distributed throughout all the biogeographical regions, except that there seem to be no records from the Ethiopian Region. No critical review of the group has ever been made and consequently it is impossible to indicate any geographical grouping of the species. On the basis of present knowledge, however, many of the species seem to be very rigidly host-limited and there is none which occurs on any wide variety of hosts.

Two other genera, *Rhizococcus* and *Gossyparia,* are at least in part synonymous with *Eriococcus,* but whether or not they are entirely so cannot be determined until extensive studies have been made.

The two species known from Hawaii, both of which are unquestionably introduced, may be separated from each other by the following key:

1. Margin of body with a single row of large setae, there being no such setae anywhere on dorsum; occurring, as far as known, only on *Araucaria*................ **araucariae** Maskell.
2. Margin of body, especially toward head with more than a single row of large setae and a few such setae present on dorsum, especially in thoracic areas; occurring, as far as known, only on cactus................... **coccineus** Cockerell.

Eriococcus araucariae Maskell (figs. 150, 151).
Eriococcus araucariae Maskell, 1879:218.

The araucaria mealybug.

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. Described from New Zealand; probably an Australian species, but now widespread. First recorded from Hawaii by Koebele in 1897 (1898:113, as *"Eryococeus araucariae"*), when he reported that it was found on all of the islands of the group.

Hostplants: *Araucaria* species; Kirkaldy's records from avocado, fig and guava (1904:153) are erroneous.

Parasite: *Aphycomorpha araucariae* Timberlake (Hymenoptera: Encyrtidae).

Predators: *Cryptolaemus montrouzieri* Mulsant, *Sticholotis punctatus* Crotch (Coleoptera: Coccinellidae).

This species is occasionally found in masses on the terminal parts of the twigs. It produces large quantities of honeydew, which in turn encourages the growth of sooty mold which blackens the infested foliage. It is particularly partial to young potted plants.

The following notes have been prepared by Ferris:

Hosts and distribution: First recorded from *Araucaria excelsa* in New Zealand, with later records from the same host in many parts of the world, apparently occurring wherever this tree is grown as an ornamental.

Habit: Occurring at the base of the needles, where it forms a little, oval, white sac, that of the male being smaller than that of the female.

Recognition characters: Length of adult female, as mounted, about 2 mm. Marginal setae arranged in a definite single row; on the abdomen there are for the most part three setae at margin of each segment, one of these noticeably smaller than others, while on thorax and head all are of the larger size; setae quite large, stout, slightly tapering and with a rounded apex. Scattered over the entire dorsum, in no apparent pattern, are numbers of very small, stout setae, each truncate and having the form of a small cylinder.

Tubular ducts of dorsum of a single size and type, these extending into lateral areas of body ventrad to marginal setae. Ducts quite large, with a slightly sclerotized tube and with cup strongly sclerotized, symmetrical or nearly so and with a deep cup. All over dorsum, equaling if not exceeding in number the tubular ducts, are ducts of another type. These are so excessively small that it requires an oil immersion lens to determine their details. Under the oil immersion lens

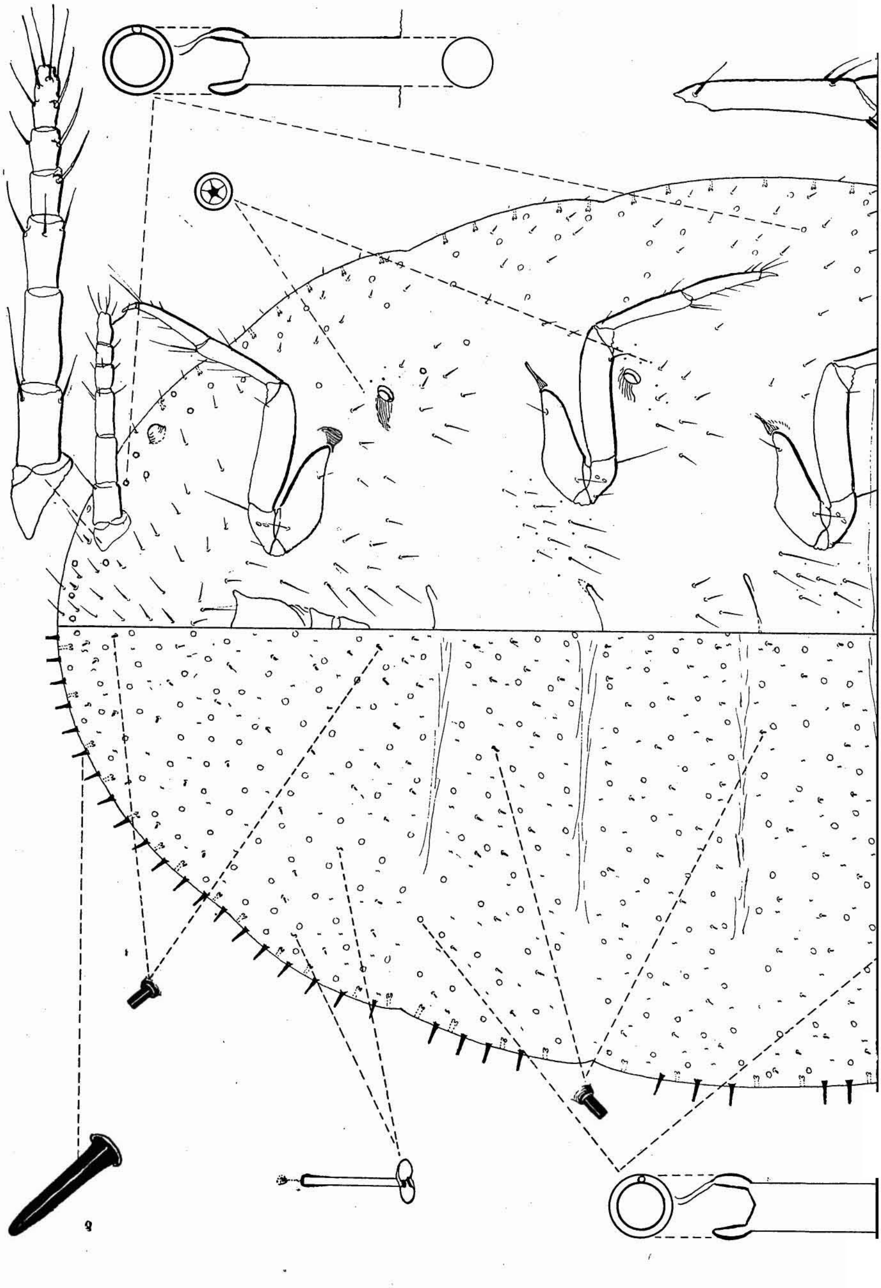
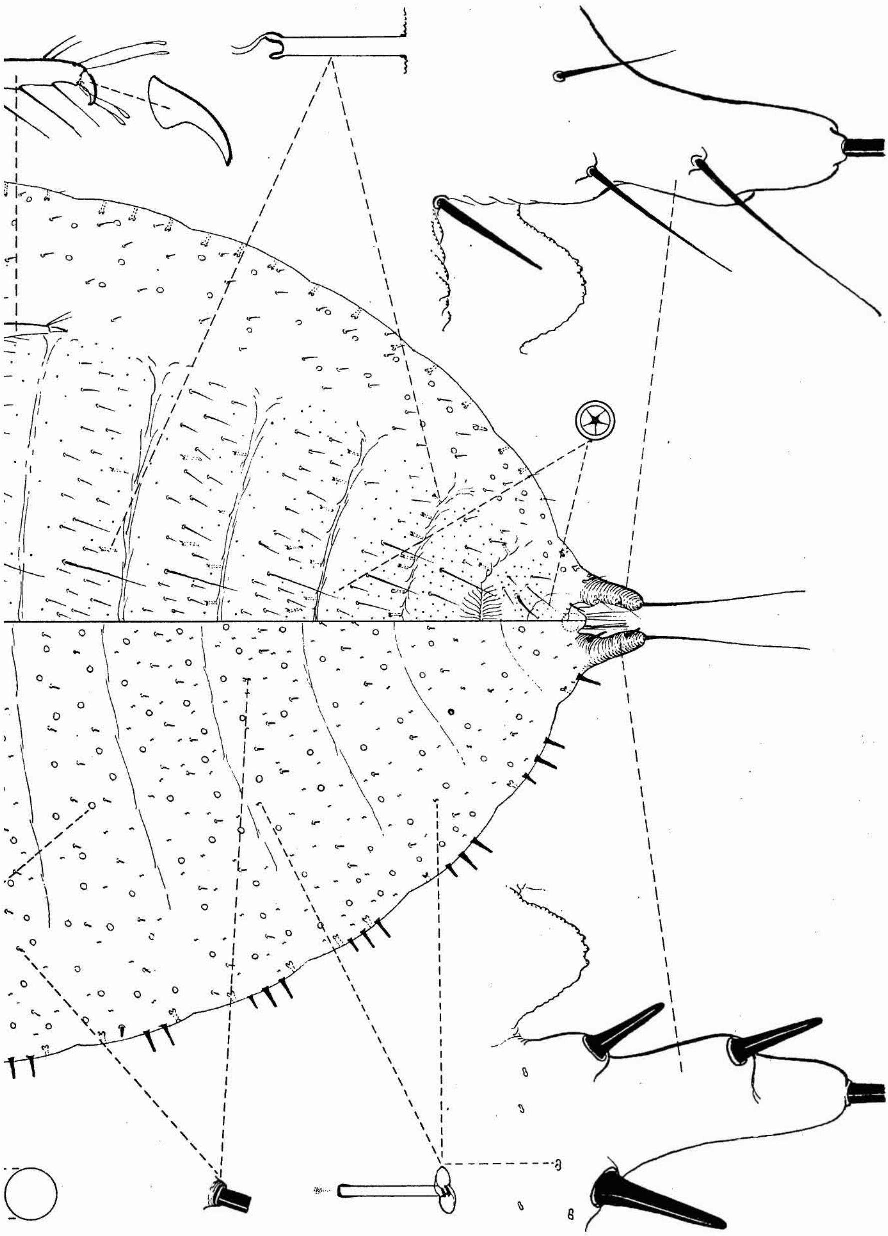


Figure 150—*Eriococcus araucariae* Maskell, the araucaria mealybug. (Drawn by Ferr



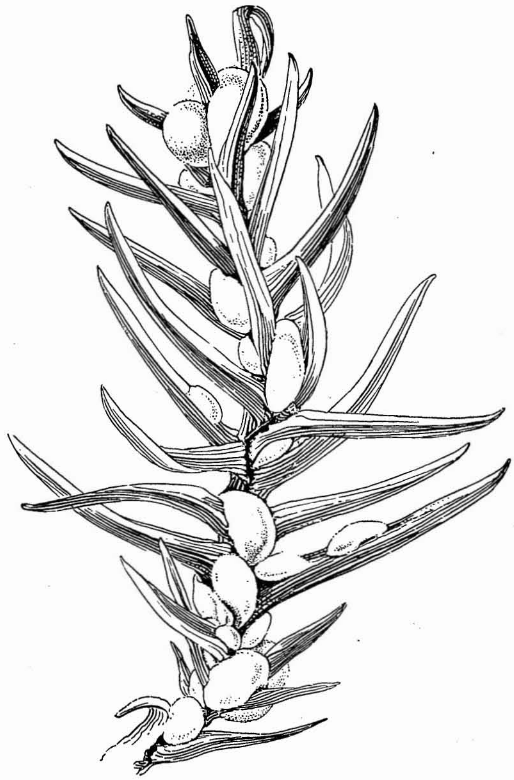


Figure 151—*Eriococcus araucariae* Maskell, the araucaria mealybug. (Abernathy drawing.)

these ducts appear as very slender tubes, each with a delicate median filament arising at inner end and with orifice surrounded by a somewhat 8-shaped sclerotization.

Anal lobes strongly sclerotized, cylindrical, their dorsal setae of same shape as those of body margin and not noticeably larger. Between anal lobes there is, dorsally, a distinct, little, triangular cauda, which is not sclerotized and beneath which the anal ring is slightly retracted. Anal ring with eight setae.

On ventral side of body the large tubular ducts are present only in marginal areas and these areas are beset with numbers of very small, slender setae. Median areas, especially of abdomen, bear numerous slender setae of various lengths and numerous exceedingly small, stellate pores. Median region of abdominal venter with very few, extremely small tubular ducts which are very slender and terminate in a small, strongly sclerotized and asymmetrical cup. Legs and antennae present no very distinctive features. Tarsal claw with a small, but distinct tooth. Antennae seven-segmented.

Notes: Apparently the identification of this species rests entirely upon an assumption which is based upon the quite inadequate original description and the host. However, the specimens at hand from the United States and Hawaii agree with the original description as far as it goes.

Eriococcus coccineus Cockerell (figs. 152, 153).
Eriococcus coccineus Cockerell, 1894:204.

Kauai.

Immigrant. Originally described from specimens taken in a greenhouse in Nebraska, but now known to be widespread in North America. First noticed in Hawaii in 1944 by Pemberton who found it at Koloa, Kauai, well established in a garden of cacti and succulents imported principally from California.

Hostplants: cacti (*Astrophytum, Cereus, Cleistocactus, Echinopsis, Mammillaria*). The scale may be abundant with the females crowded into the furrows in the cactus.

Professor Ferris has supplied the following comments:

Hosts and distribution: There seem to be few published records of the species under this name, although such may exist in local lists, but the opinion is here held that *Eriococcus cactearum* Leonardi (Bolletino del Laboratorio di Zoologia generale e agraria della R. Scuola superiore d'Agricoltura in Portici 12:206, 1918) recorded from "*Cereus* sp., *Mammillaria* sp., *Echinopsis* sp.," in Italy is the same. Specimens are at hand from unspecified cacti in greenhouses at various localities in the United States.

Habit: At full maturity the adult females have a tendency to move out on the spines, upon which they form their small, oval, white ovisacs.

Recognition characters: Length of adult female, on slide, about 1.75 mm. Margins of body with an irregular double row of stout, tapering, apically truncate setae of two sizes. On abdominal segments there are, for the most part, three setae at margin of each segment, one of these being considerably larger than others, and in addition there is a small seta slightly ventrad of these three. On thoracic and head areas these ventral setae become more numerous and two quite distinct rows are formed, most of these setae being of much the same size. In thoracic area there is a variable number of setae of various sizes present in middle of dorsum. These are subject to some variation and at times extend onto first one or two abdominal segments. In addition to these large setae there are present over dorsum, especially on abdomen, a very few extremely small cylindrical setae with truncate apex.

Dorsal tubular ducts few, quite large, tube so extremely delicate that even in well-stained specimens it is difficult to trace, so much so that the heavily sclerotized, broad, symmetrical cups seem to be detached from body wall. There are a few excessively minute structures which perhaps represent the minute ducts described for *Eriococcus araucariae,* but they are so small that they remain indeterminate and may be dismissed.

Anal lobes well developed, but rather short and weakly sclerotized, their stout dorsal setae of same form as those of body margin and of same sizes. Between anal lobes is a small, dorsal cauda, which is so membranous and minute that it can easily be overlooked.

Ventral side of body with a few large tubular ducts in marginal regions and with a single row of small, stout setae, in form like those of dorsum, somewhat

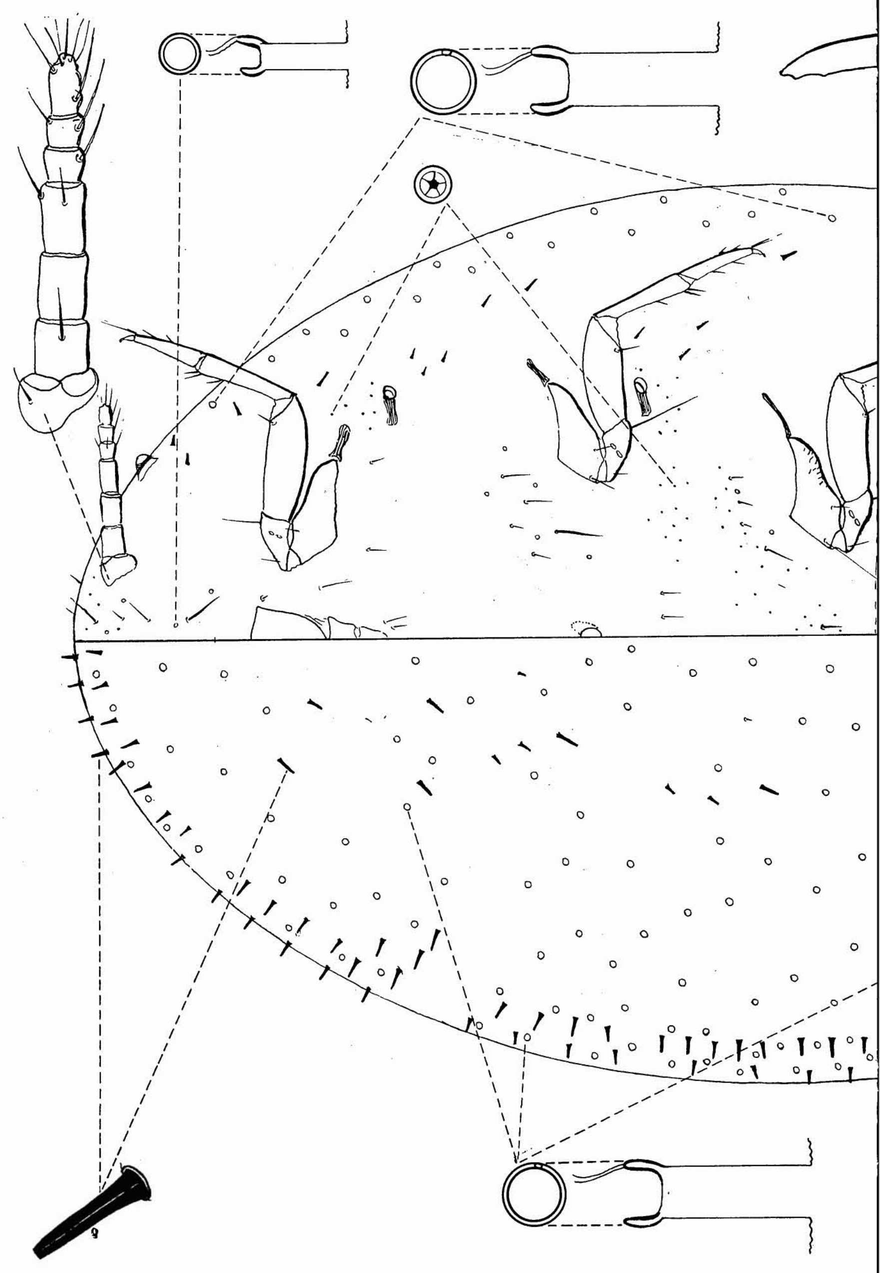
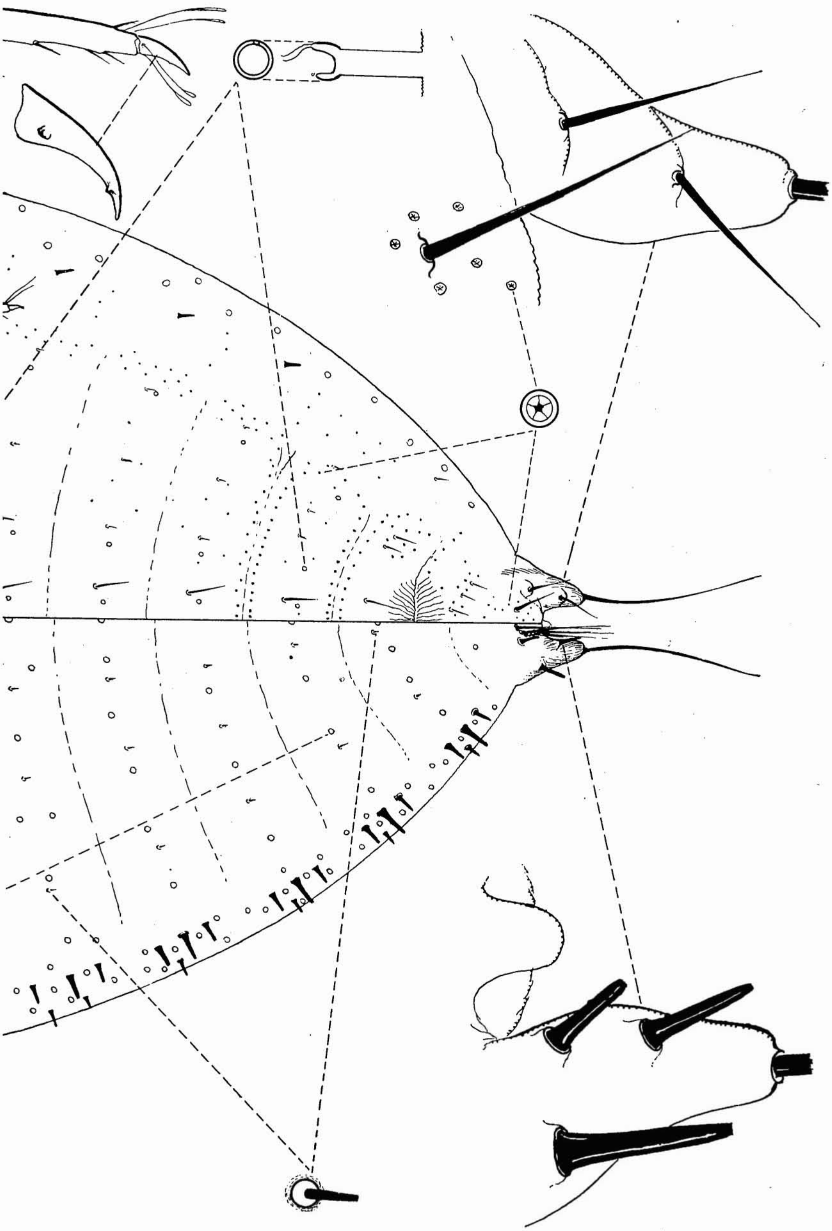


Figure 152—*Eriococcus coccineus* Cockerell. (Drawn by Ferris.)



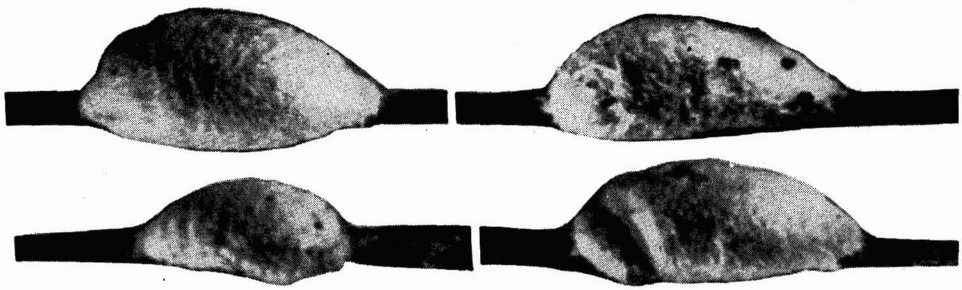


Figure 153—*Eriococcus coccineus* Cockerell, on cactus thorns.

removed from margin, and two or three such setae near each spiracle. There are a few extremely small, stellate pores in midregion of abdominal venter and among setae on thorax and even head. Ventral setae very sparse, mostly extremely small. A very few small, tubular ducts with somewhat asymmetrical cup appear scattered over midregion of venter, even to head. Anal ring with eight setae. Antennae seven-segmented. Legs with no distinctive features. Tarsal claw without a tooth.

Notes: Ferris has at hand specimens which have been compared with the types of the species.

Family **COCCIDAE** Stephens, 1829

The Soft Scales, Tortoise Scales

As diagnosed by Steinweden (1929:198) the family may be characterized as follows: Adult female with "an anal cleft the base of which is covered by an operculum formed of two plates; anal opening invaginated and surrounded by a distinct, setigerous anal ring; usually with four stigmatic depressions with prominent stigmatic setae; usually with well developed legs and antennae. Without abdominal spiracles, dorsal ostioles, cerarii, or brachii."

Although the females may be sedentary in later life, nearly all our species have well-developed legs and antennae. They may be nearly naked or may have a scale or a heavy mass of wax which conceals the body, or, as in *Pulvinaria*, a cottony eggsac is produced. The eggs or young are produced in masses beneath the body of the female, which becomes ventrally concave to form a protective covering over them.

This family contains a number of agricultural pests. All the species found in the Hawaiian Islands are widespread immigrants. Most Coccidae produce large amounts of honeydew which, in turn, give rise to heavy growths of unsightly mold.

This is a difficult group to work with, and it is in an unsatisfactory taxonomic condition at present. The appearance of many of the species alters greatly in the course of development, so much so that many of the species appear under two distinct guises. The immature stages, including the early portion of the last instar, may be thin, flat and membranous, but when growth is completed the body may become greatly swollen and the dorsal derm may become extremely thick and sclerotic. It is almost impossible to make satisfactory microscopic preparations of these fully grown, sclerotized individuals, and, at the same time, the membranous, flat immature forms are sometimes difficult to obtain. Consequently, in the past the classification of the group has been based chiefly upon the gross appearance of the fully mature female. The result is that the genera are but poorly defined and in some cases are evidently quite artificial. Nothing short of an extensive review of the entire group will make possible the remedying of this situation. However, when good preparations can be obtained from early adult females, it is possible to recognize the presence of characters which are definitive in the identification of species. The accompanying illustrations have been based upon such material. (This paragraph contributed by Ferris.)

Key to the Genera of Coccidae Known to Occur in Hawaii

(Prepared for this text by G. F. Ferris.)

Note: *Protopulvinaria* is included in this key for comparative purposes, but the genus is not known to occur in Hawaii.

1. Stigmatic depressions beset with numerous tubercle-like setae; female at maturity, or even in earlier stages, covered with a mass of amorphous wax...**Ceroplastes** Gray.
   Not so; stigmatic depressions normally with but three enlarged setae 2

2(1). Anal plates elongate, anterior-lateral margin of each plate being from two to six times as long as posterior-lateral margin 3
   Anal plates more nearly quadrate, anterior-lateral margin of each plate usually shorter than posterior-lateral margin 4

3(2). Adult female secreting a small, fringe-like ovisac; ventral side of abdomen with a submarginal zone of small tubular ducts, each with a strongly sclerotized rim, from which the ovisac presumably is produced.......................................**Protopulvinaria** Cockerell.
   Adult female not secreting an ovisac and without ventral tubular ducts..some species now referred to **Coccus** Linnaeus.

4(2). Adult female with dorsal derm strongly sclerotized and divided by membranous furrows into a pattern of quite large plates.....................**Eucalymnatus** Cockerell.
   Adult female with derm of dorsum not thus divided into plates 5

5(4). Adult female with a ventral, submarginal zone of tubular ducts extending forward from margin of anal cleft at least to thorax.. 6
   Adult female without ventral tubular ducts except at times in thoracic region........some species of **Coccus** Linnaeus.

6(5). Adult female secreting an ovisac from ventral zone of tubular ducts; body remaining quite flat at full maturity, usually with dorsal derm only weakly sclerotized; tibio-tarsal articulation definitely flexible; base of tarsus usually narrower than apex of tibia and tarsus tending to be curved; anal plates always without discal setae..........................**Pulvinaria** Targioni-Tozzetti.
   Adult female never with an ovisac; body tending to be convex at full maturity; with dorsal derm strongly sclerotized and marked with polygonal reticulation, or with many small, oval, clear areas; tibio-tarsal articulation tending to be apparently inflexible; base of tarsus as wide or nearly as wide as apex of tibia, and tarsus straight or but very slightly curved; anal plates in some species each with a large discal seta....**Saissetia** Déplanche.

Genus **COCCUS** Linnaeus, 1758:455

As at present employed this genus is almost undefinable, since it has generally been based solely upon the superficial habit characters of the adult female. Thus the genus has been made to include forms that have little in common other than that they remain flat or become but slightly convex at full maturity and that they form no ovisac or other evident waxy secretion. The genus consequently includes some rather diverse forms which form no unified morphologically definable group. On the basis of present usage the genus may be recognized as follows: Species which at full maturity remain flat or become but little convex; with no dorsal secretion other than a mere film; never secreting an ovisac; derm of the dorsum usually membranous or but little sclerotized, although in one species it is strongly sclerotized. Antennae and legs usually well developed, although in one species they are reduced. Tibio-tarsal articulation not free, or but slightly so. Tubular ducts on ventral side of the body either lacking or present in small numbers, never arranged in a distinct, submarginal zone. (Ferris.)

The following key has been formed by the combining of keys prepared for me by Ferris and Morrison.

Key to the Species of Coccus Known to Occur in Hawaii

1. Anal plates noticeably elongated, antero-lateral margin of each plate at least twice as long as postero-lateral margin, with outer angle near posterior apex 2
   Anal plates together presenting an approximately quadrate shape, postero-lateral margin of each plate usually slightly longer than antero-lateral margin 3

2(1). Mid and hind coxae much enlarged and misshapen, femora elongated .... **acuminatus** (Signoret).
   Mid and hind legs normally developed ..... **mangiferae** (Green).

3(1). Antennae and legs noticeably reduced, antennae three- to six-segmented, legs short and stout 4
   Antennae and legs normally developed, slender; antennae seven- or eight-segmented 5

4(3). Antennae three-segmented, third segment much elongated; legs without tibio-tarsal articulation; body slender and elongate .... **acutissimus** (Green).
   Antennae five- to seven-segmented; legs with tibio-tarsal articulation distinct; with numerous (perhaps 80 to 100) small but fairly conspicuous discs spread along and near mid-line dorsally between anal plates and antennae; body ovoid, not long and slender .... **pseudohesperidum** (Cockerell).

5(3). An elongate-oval species; anal region normally with six to eight fringe setae on fold leading into anal tube (beneath anal plates); each anal plate with a "discal seta" (this is situated toward apex, and is associated with three other similar dorsal setae on apical angle, see fig. 156); antennae normally eight-segmented .... **elongatus** (Signoret).

Broadly ovoid species; anal region normally with only four fringe setae on fold leading into anal tube; anal plates with "discal setae"; antennae normally seven-segmented 6

6(5). Ventral multilocular disc pores restricted to a cluster about base of anal cleft, below anal plates, and a few may be present on abdominal segments immediately anterior to these; tubular ducts entirely lacking; marginal setae elongate, entire or only slightly cleft or fimbriate apically............................ **hesperidum** Linnaeus.

Ventral multilocular disc pores, although few and often difficult to locate, present in midregion of abdominal venter as far forward as thorax; tubular ducts present in midregion of thoracic venter; marginal setae small, short, broadly and strongly fimbriate...... **viridis** (Green).

Coccus acuminatus (Signoret) (fig. 154).

Lecanium acuminatum Signoret, 1873:397, pl. 12, fig. 1.

Protopulvinaria acuminata (Signoret) Steinweden, 1929:223.

The acuminate scale.

Oahu.

Immigrant. First recorded from Hawaii by Maskell in 1895 (p. 14) from specimens collected by Koebele. It was described from material collected from hothouse orchids at Luxemburg.

Hostplants: *Aglaia, Eugenia malaccensis,* guava, lemon, lime, mango.

Parasites: Koebele (1898:112) stated that "It is always badly parasitized in Honolulu by two species of Chalcid flies"; I do not have further records.

Perkins reported that a native drepaniid bird (*Chlorodrepanis*) fed heavily on this scale (*Proc. Hawaiian Ent. Soc.* 2(4):174, 1912).

According to Ehrhorn, this species was confused by Kotinsky with *Coccus mangiferae* which it closely resembles. He gave details of this confusion in Hawaiian literature and made the correction (1912:148). However, see our notes under *Coccus mangiferae.*

The following information has been supplied by Professor Ferris:

Habit: Occurring, in material at hand, on leaves. Very flat, broad, with anterior end somewhat acuminate. Available dried specimens somewhat yellow, with a narrow, paler stripe extending toward meson from each stigmatic depression and one such on each side about halfway between posterior depression and posterior end of body. In dried specimens derm has a slightly tessellate appearance.

Recognition characters: Length on slide about 3 mm. in the largest specimens at hand. Derm at full maturity slightly sclerotized about margins. Scattered over dorsum are a very few minute pores and minute, clavate setae, while just anterior to anal plates there is a small median group of minute, oval pores. Anal plates set at about one-third of length of body from posterior margin, elongate; anterior-lateral margin slightly less than twice as long as posterior-lateral margin. Antennae

well developed and slender, variable in segmentation but most commonly seven-segmented in material at hand. Anterior legs of normal form and size, but middle and posterior legs with coxae greatly enlarged and of peculiar form, femur elongate and about twice as long as combined tibia and tarsus. Stigmatic depressions with normal three stout setae, center one about twice as long as other two. Marginal setae arranged in a quite closely set single row, setae short, slender and, with few exceptions, dichotomously or twice-dichotomously branched.

Notes: Whether or not this species is actually that described by Signoret is uncertain, but it has passed under the name of *acuminatus* and this name may, for the present, be accepted. It is one of a series of species which have the same general appearance, with the anal plates elongate and set well forward. Among these species it is one of a second series in which the middle and posterior legs have the coxa enlarged and the femur elongate. At least two species of this second series have been named, these being *Coccus diversipes* Cockerell from the Philippine Islands and *Lecanium wardi* Newstead from British Guiana. In *diversipes* the middle and posterior femora are even longer and more slender than in *acuminatus,* the posterior tibiae terminate in a distinct spur and a median stripe that is crowded with small, oval, 8-shaped pores extends from the anal plates almost to the apex of the head, while there is a distinct patch of such pores between the margin and the midline, just anterior to the anal plates. The description of *wardi* omits reference to the pores, but specimens are at hand from Venezuela which are perhaps that species. These agree quite closely with specimens from Hawaii, differing only in being somewhat more sclerotized at maturity.

In the opinion here held these species do not belong to the genus *Coccus,* but their generic disposition awaits further study.

The accompanying figures are based upon specimens from *Eugenia* and mango from Hawaii.

Coccus acutissimus (Green) (fig. 155).

Lecanium acutissimum Green, 1896:10.

Oahu.

Immigrant. A nearly cosmopolitan species, described from Ceylon. First recorded from Hawaii by Ehrhorn in 1921, from specimens collected in Honolulu in 1917.

Hostplants: coconut, litchi, "palms," *Smilax*.

Ferris is responsible for the following data:

Habit: Occurring on leaves. A long, slender species, which at maturity is dark brown or black, with dorsal derm becoming strongly sclerotized. Length as much as 5 mm. Individuals tend to take up a position alongside a leaf vein and to become asymmetrical.

Recognition characters: At full maturity derm becomes deeply sclerotized except for a paler marginal zone. In some specimens the derm is slightly mottled, but in others is uniformly pigmented with a few pinhole spots sparsely scattered about.

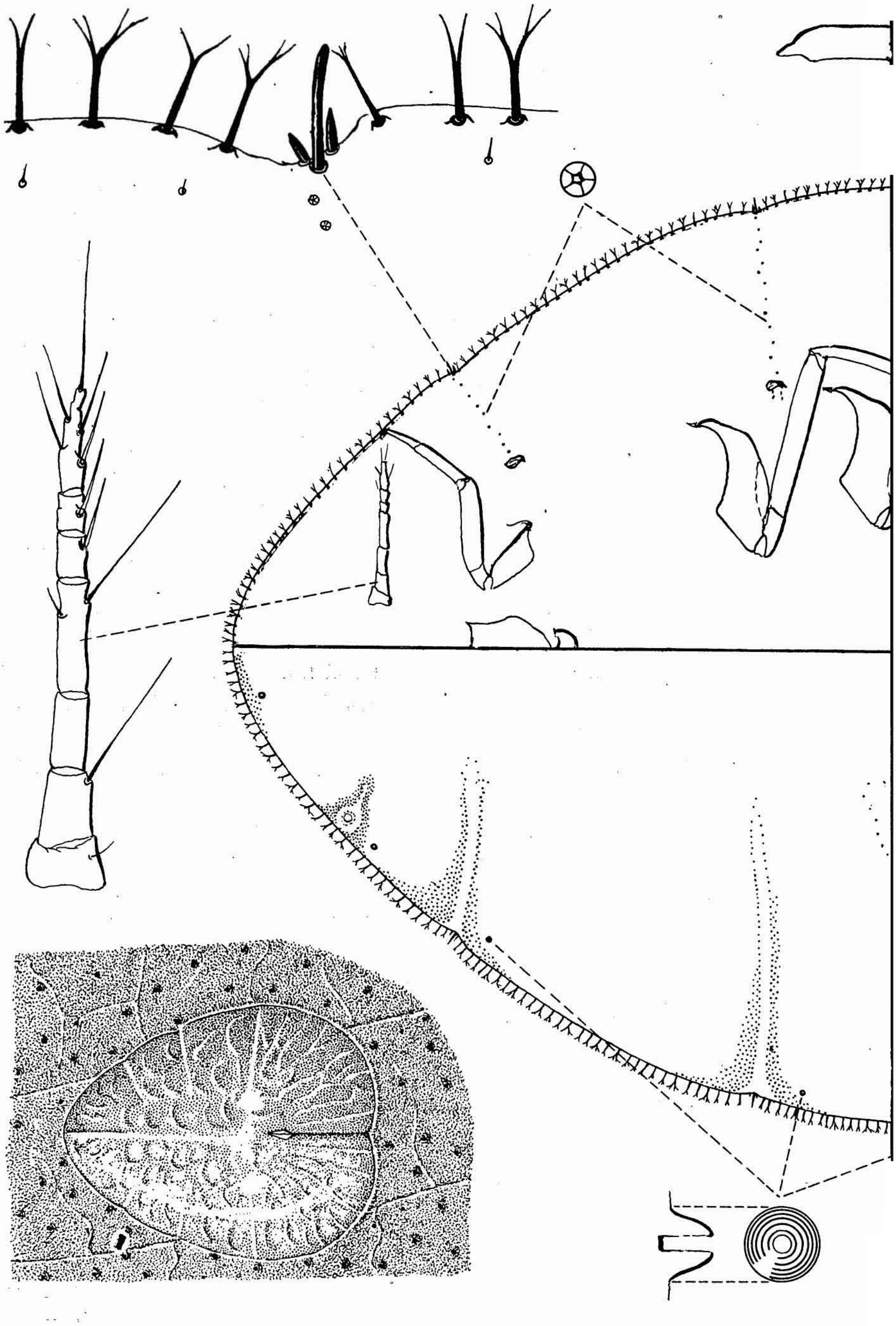
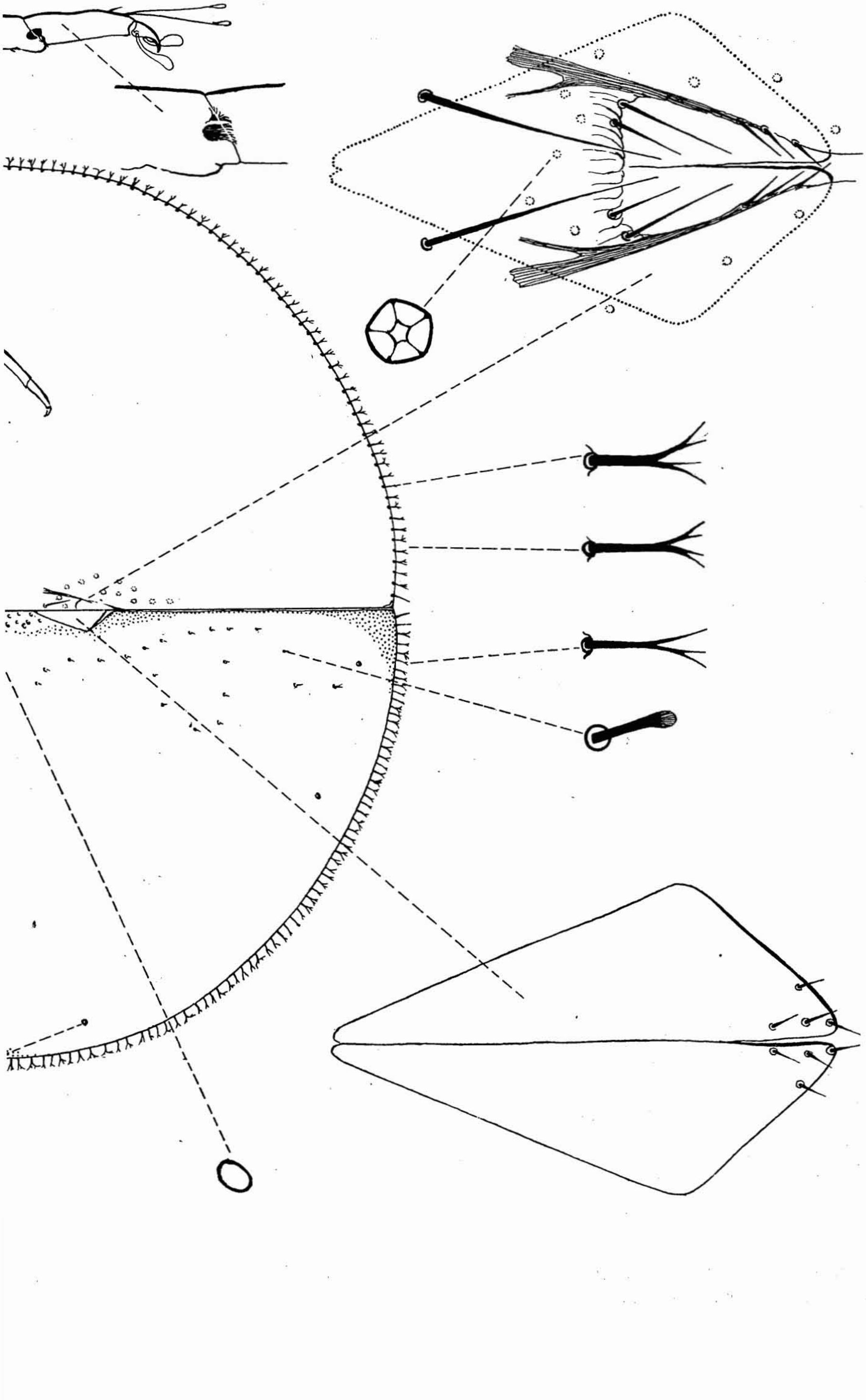


Figure 154—*Coccus acuminatus* (Signoret), the acuminate scale. (Drawn by Ferris from material from *Eugenia* and mango from Honolulu.)



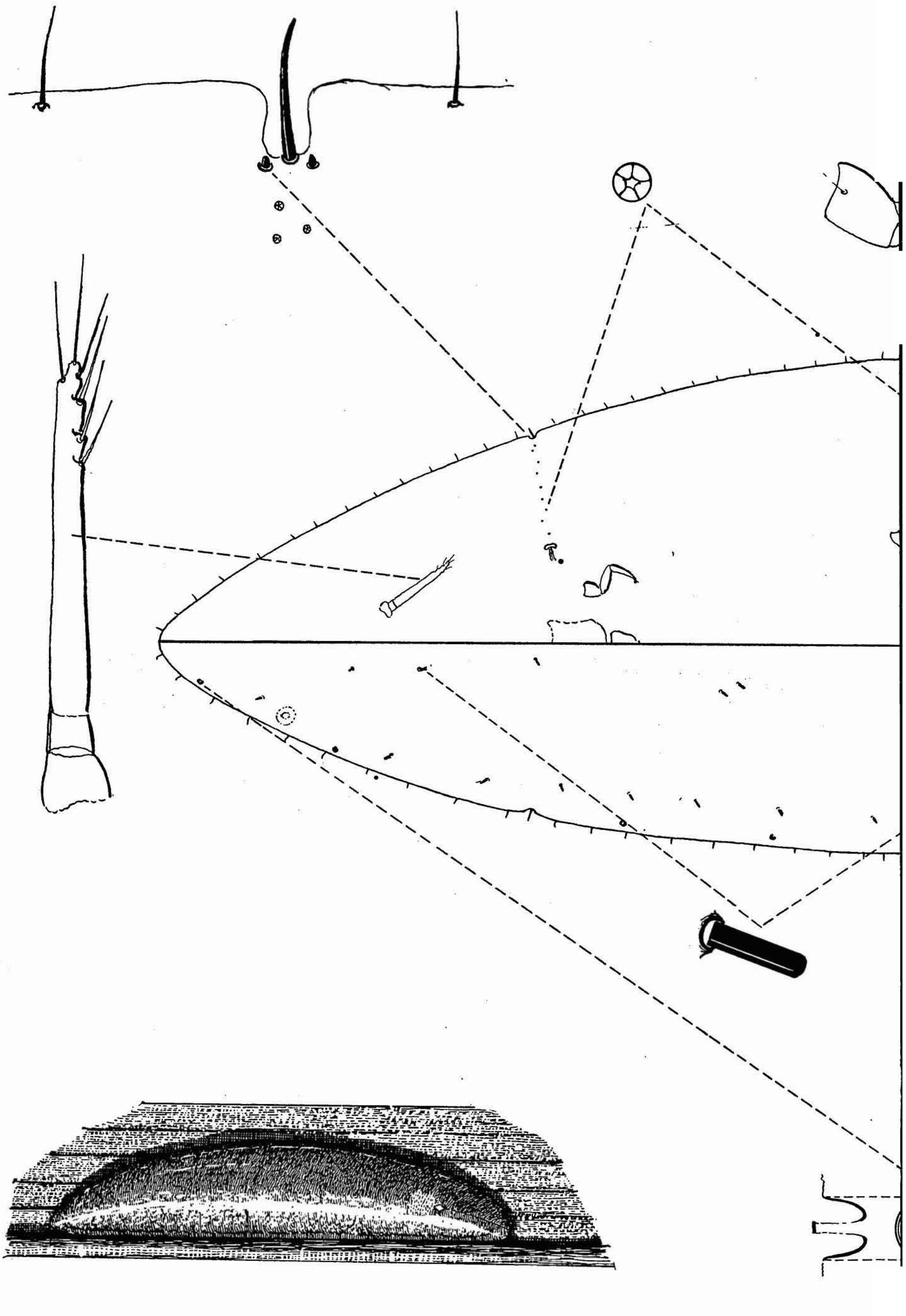
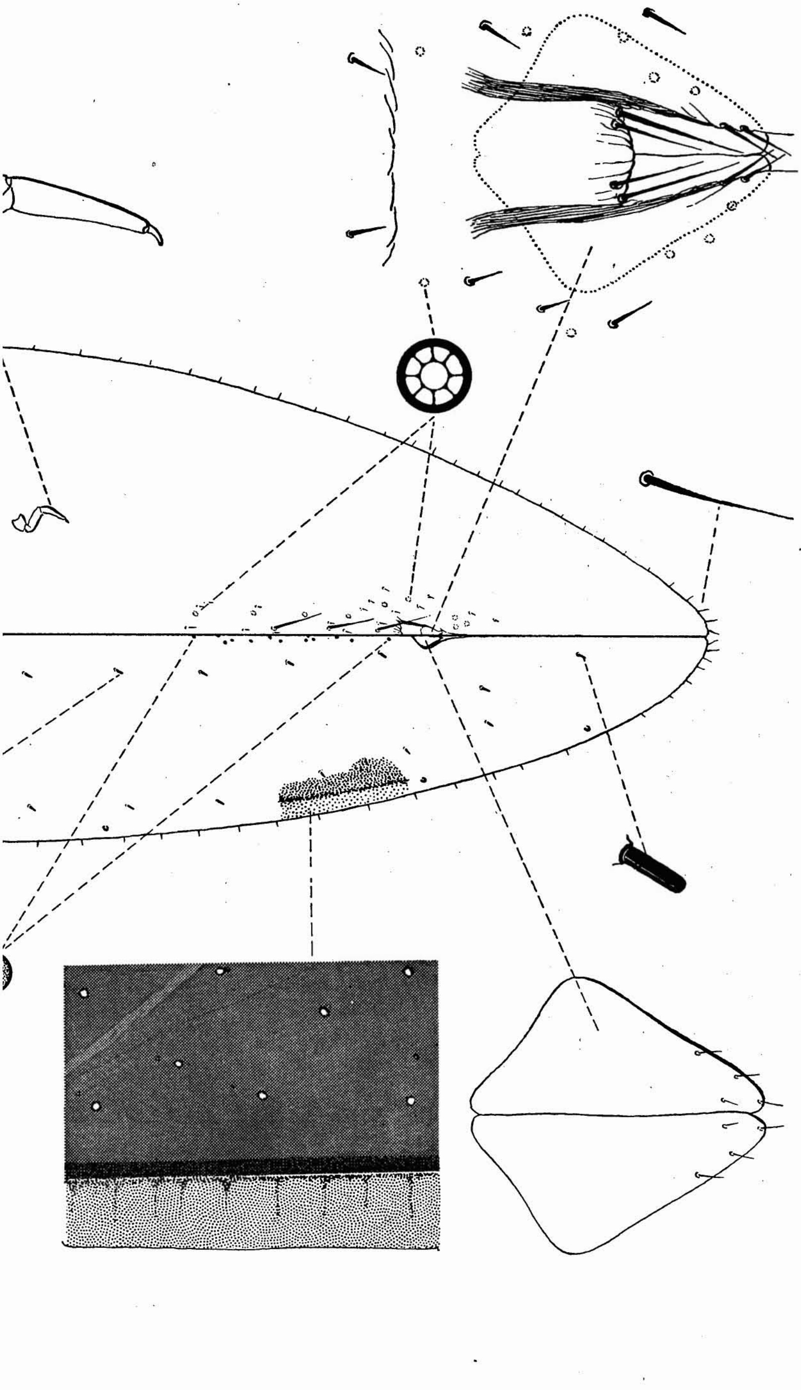


Figure 155—*Coccus acutissimus* (Green). (Drawn by Ferris from material determined b| Green from palm in Ceylon.)



Normally there seems to be a small, pale area just in front of anal plates. In unsclerotized individuals dorsum shows no structures except a few small, disc pores just anterior to anal lobes and a few small, stout, parallel-sided setae. Marginal setae all very small and slender. Anal plates of ordinary form, slightly elongate, there being four fringe setae beneath them. Ventral side of body apparently without ducts or pores except for a few multilocular disc pores about base of anal cleft and in the midregion of abdominal segments anterior to vulva. Antennae apparently only three-segmented, consisting mostly of the elongate third segment. It is probable that subdivision of this long segment may at times occur. Legs much reduced, stout, with no tibio-tarsal articulation.

Notes: I agree with the opinion previously expressly by Steinweden (1929:223) that this species is not properly referable to the genus *Coccus,* but the naming of a new genus for it should wait upon the development of comprehensive studies.

The accompanying illustrations are based upon specimens taken on palm in Ceylon, and which were determined by and received from E. E. Green.

Coccus elongatus (Signoret) (fig. 156).

Lecanium elongatum Signoret, 1873:404, pl. 12, fig. 6.
Lecanium ficus Maskell, 1897:243.
Coccus elongatus (Signoret) Sanders, 1909:438, pl. 19, fig. 12.

The long brown scale.

Oahu.

Immigrant. A widespread species first listed from the Territory by Maskell in 1895 (p. 15, as *Lecanium longulum*).

Hostplants: *Acacia, Bambusa, Citrus,* coconut, *Cosmos,* guava, lima bean, *Metrosideros* (?), orange, papaya, *Plumeria,* velvet bean.

Parasites: *Microterys kotinskyi* (Fullaway), *Aphycus alberti* Howard (Hymenoptera: Encyrtidae); *Aneristus ceroplastae* Howard (Hymenoptera: Aphelinidae). It has been reported to be heavily attacked by a fungus (*Entomophthora pseudococci*?).

This species has appeared in Hawaiian literature under the names *Lecanium longulum, Coccus longulus* and *Lecanium chirimollae.*

The following notes are by Ferris:

Hosts and distribution: First recorded by Signoret from "laurel-cherry," in France. Later described by Douglas as *Lecanium longulum,* under which name it was recorded from many hosts in almost all parts of the tropical and subtropical world. Specimens are at hand from undetermined hosts in Hawaii.

Habit: A rather elongate oval species, at maturity more or less dark brown in dried specimens, gray in life, the margins flat, the median portion somewhat convex.

Recognition characters: In specimens at hand length reaches about 4 mm. on slide; in some on *Ficus,* Stanford University greenhouse, 6 mm. At full maturity derm of dorsum becomes slightly, but quite definitely, sclerotized and is marked by small, oval, clear areas which are scattered quite regularly over entire surface.

Dorsum sparsely beset with extremely small, simple setae. Margin with a single row of quite widely spaced, slender setae, which are for most part acute at apex or occasionally very slightly fimbriate apically. Stigmatic setae of normal form, median seta slightly more than twice as long as other two. Antennae eight-segmented. Legs presenting no unusual characteristics. Anal plates with posterior-lateral margin very slightly longer than anterior-lateral; dorsally with four very small apical setae; ventrally with six or eight "fringe setae" along fold leading into anal invagination. Marginal tubercles present (there being as many as seven) and showing a tendency to be slightly sunken into derm. Dorsum apparently with no circular pores anterior to anal plates. Apparently no tubular ducts present. A few small multilocular disc pores present ventrally in area about, and anterior to, base of anal cleft. Stigmatic furrows with an irregularly double row of very small stellate pores.

Notes: In all specimens examined, there are from six to eight fringe setae on fold of anal invagination beneath anal plates, this contrasting with but four in other species of the genus here considered. This, combined with the slender, apically acute marginal setae and the minor characters indicated, renders the identification of the species quite easy.

The identification of this species as the *Lecanium elongatum* of Signoret depends upon the work of Sanders (1909), who had available material determined by Signoret himself. Sanders indicated also that *Lecanium ficus* Maskell is a synonym of *Coccus elongatus*. Specimens from the type material of this are at hand and entirely support this view. The accompanying figures are based upon this material.

Coccus hesperidum Linnaeus (figs. 157, 158).

Coccus hesperidum Linnaeus, 1758:455.

Sanders, 1909:436, pl. 19, fig. 4.

The soft brown scale.

Oahu, Maui, and probably on all the main islands.

Immigrant. Cosmopolitan. First recorded from Hawaii by Craw in 1896 (p. 40).

Hostplants: *Citrus, Moraea bicolor, Moraea iridioides,* orange, orchids, papaya, rubber, *Santalum haleakalae.*

Parasites: *Aphycus alberti* Howard, *Anicetus annulatus* Timberlake (Hymenoptera: Encyrtidae).

The following paragraphs are by Ferris:

Habit: Occurring on leaves and on younger, chlorophyll-bearing twigs. Usually quite regularly oval and symmetrical, although occasionally an asymmetrical specimen may be found where it has been crowded against a leaf vein; very slightly convex; pale yellowish-brown, in life flecked with irregular brown spots.

Recognition characters: Length about 3.5–4.0 mm. Derm at maturity remaining membranous or at most with but a very slight suggestion of sclerotization. In specimens in which this sclerotization is present, small, sparsely distributed areolations can be detected. Otherwise dorsum entirely without pores or structures other

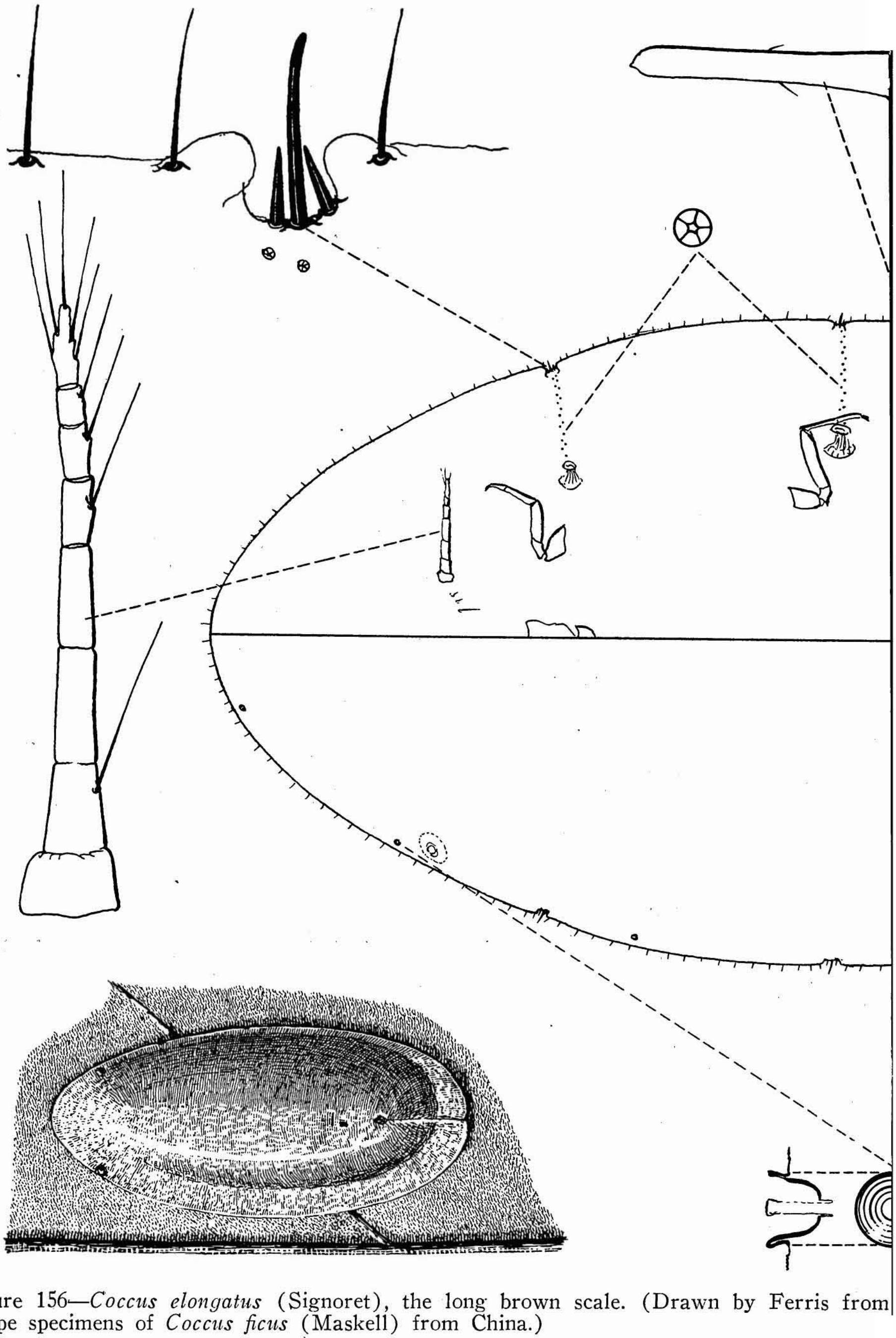
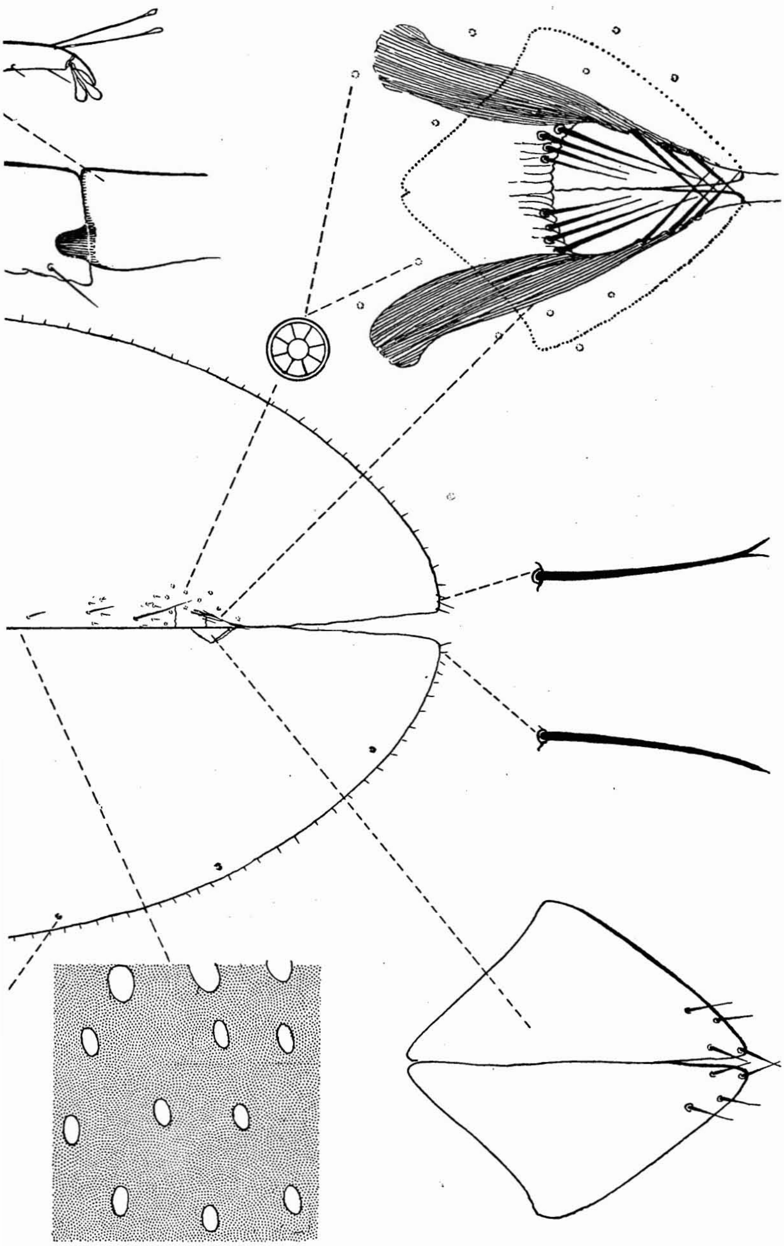


Figure 156—*Coccus elongatus* (Signoret), the long brown scale. (Drawn by Ferris from the type specimens of *Coccus ficus* (Maskell) from China.)



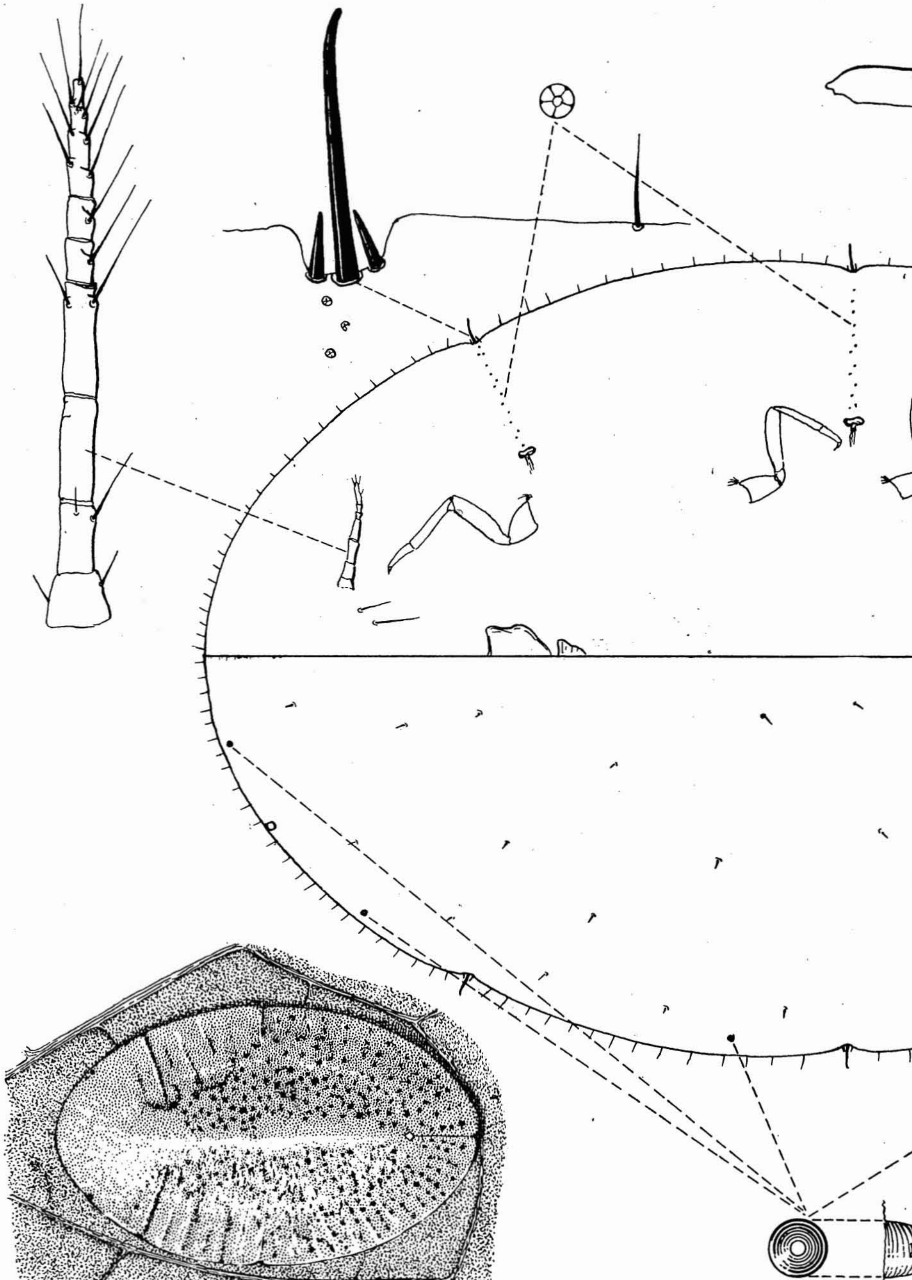
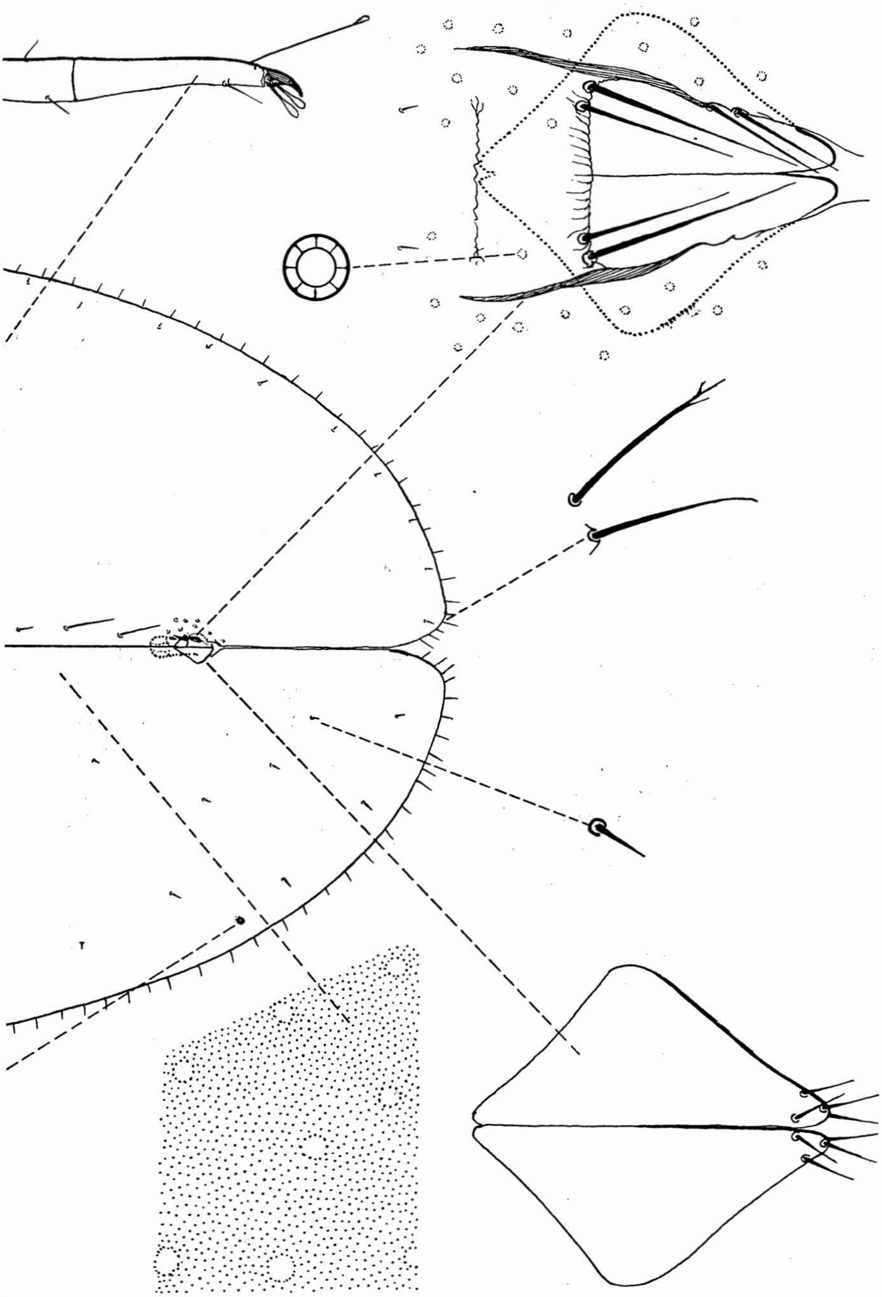


Figure 157—*Coccus hesperidum* Linnaeus, the soft brown scale. (Drawn by Ferris.)



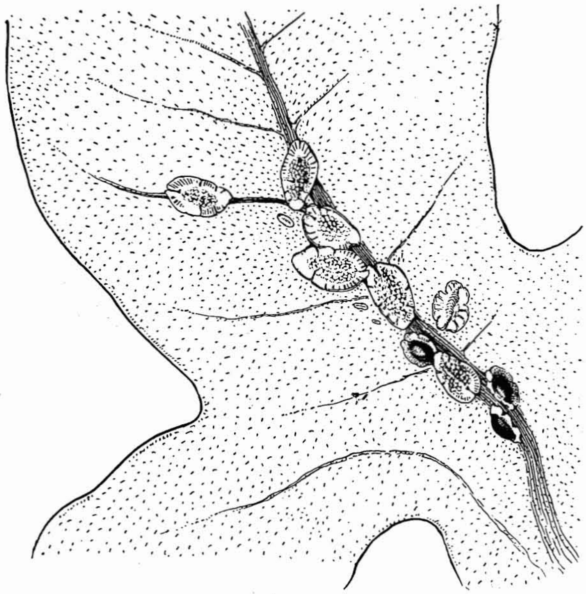


Figure 158—*Coccus hesperidum* Linnaeus, the dark individuals are parasitized. (Abernathy drawing.)

than a very few extremely minute, sharply pointed setae. Marginal setae in a single row, all quite small and slender and usually without fimbriations, although in some specimens a few setae are very slightly branched near apex. Stigmatic depression with one long and two short, stout setae. Three or four very small submarginal tubercles present on each side of body. Anal plates almost quadrate, being very slightly longer than their combined width, with three very small, apical and subapical setae; ventrally with two slender subapical setae and two fringe setae on each side. On ventral side, in region immediately surrounding base of anal plates is a small group of multilocular pores. Tubular ducts lacking. Antennae well developed, normally seven-segmented. Legs well developed, tibio-tarsal articulation being a mere line and without any articulatory sclerosis. Near base of each antenna is a pair of slender setae. Pores of stigmatic furrows in an irregular single row.

Notes: This is a featureless species, but this very featurelessness makes it readily identifiable among the species now known from Hawaii.

The accompanying illustrations are based upon specimens from loquat (*Eriobotrya*) Stanford University, California.

Coccus mangiferae (Green) (fig. 159).

Lecanium mangiferae Green, 1889:249, figs. 1–4.

Oahu.

Immigrant. A widespread tropical species. As far as we know, Koebele took the first specimens of this species in Honolulu before 1900. The first record in

Hawaiian literature that I have seen is as follows: "Mr. Kotinsky also reported the finding of (*Lecanium*) *Coccus mangiferae* (Green) in injurious numbers upon the Alfons (Indian) variety of mango in the Moanalua Gardens. Mr. Craw believed that he had observed the same scale upon trees in Mr. Giffard's yard; Mr. Giffard thought that such would not be impossible, since he has frequently exchanged plants with the Gardens." (*Proc. Hawaiian Ent. Soc.* 1:32, 1906.) However, Ehrhorn (1912:147–148) stated that he had examined this material, and that he considered that it was *Coccus acuminatus* instead of *mangiferae*. The material from which Professor Ferris has made the accompanying drawing was collected by Koebele in 1894 at Honolulu, but we have no fresh data on the present status of the species in the Territory.

Hostplants: mango; Fernald (1903:172) records it also from cinnamon, nutmeg, breadfruit, jasmine, *Allamanda*, sapodilla and *Ixora*, all of which grow in Hawaii and which may be hosts here.

Comments by Ferris follow:

Habit: Described as occurring on leaves of host. In life, pale yellowish-green; in dried specimens pale yellow. Flat and thin, broadly pyriform. Wrinkling of dorsum in dried specimens causes formation of little ridges that seem to define polygonal areas.

Recognition characters: Derm of dorsum, at full maturity, very slightly sclerotized except for a pale stripe extending in from each stigmatic furrow and four or five such stripes along margin of abdomen. Dorsal derm is marked with small, circular, clear areas, each usually with a dark rim, which are scattered sparsely about. A few very small setae with slightly clavate apices on dorsum. There seem to be no disc pores anterior to anal plates. Anal plates set at about one-third of length of body from posterior margin, plates elongate, anterior-lateral margin of each plate being about twice as long as posterior-lateral margin, combined width of plates being about one-half their length. Marginal setae in a quite closely set, evenly spaced single row, setae slender, variously branched or fimbriate at apices. Submarginal tubercles present. On ventral side there is a small cluster of multilocular disc pores about base of anal cleft and around region of vulva, but apparently none elsewhere. There seem to be no tubular ducts. Antennae normally developed, seven- or eight-segmented. Legs normally developed, none of coxae enlarged, tibio-tarsal articulation having a strongly developed articulatory sclerosis and apparently free.

Notes: The accompanying illustrations are from specimens in the Koebele Collection, Number 1378, from unspecified host, Hawaii. These specimens agree quite closely with the description given by Green and the identification seems reasonably certain.

From the very similar *Coccus acuminatus* (Signoret) this species may immediately be separated by the fact that in *mangiferae* the coxae of the middle and posterior legs are of normal size and form, while in *acuminatus* they are enlarged and misshapen. It seems probable that these two species have been confused at times and records of their occurrence need to be re-examined.

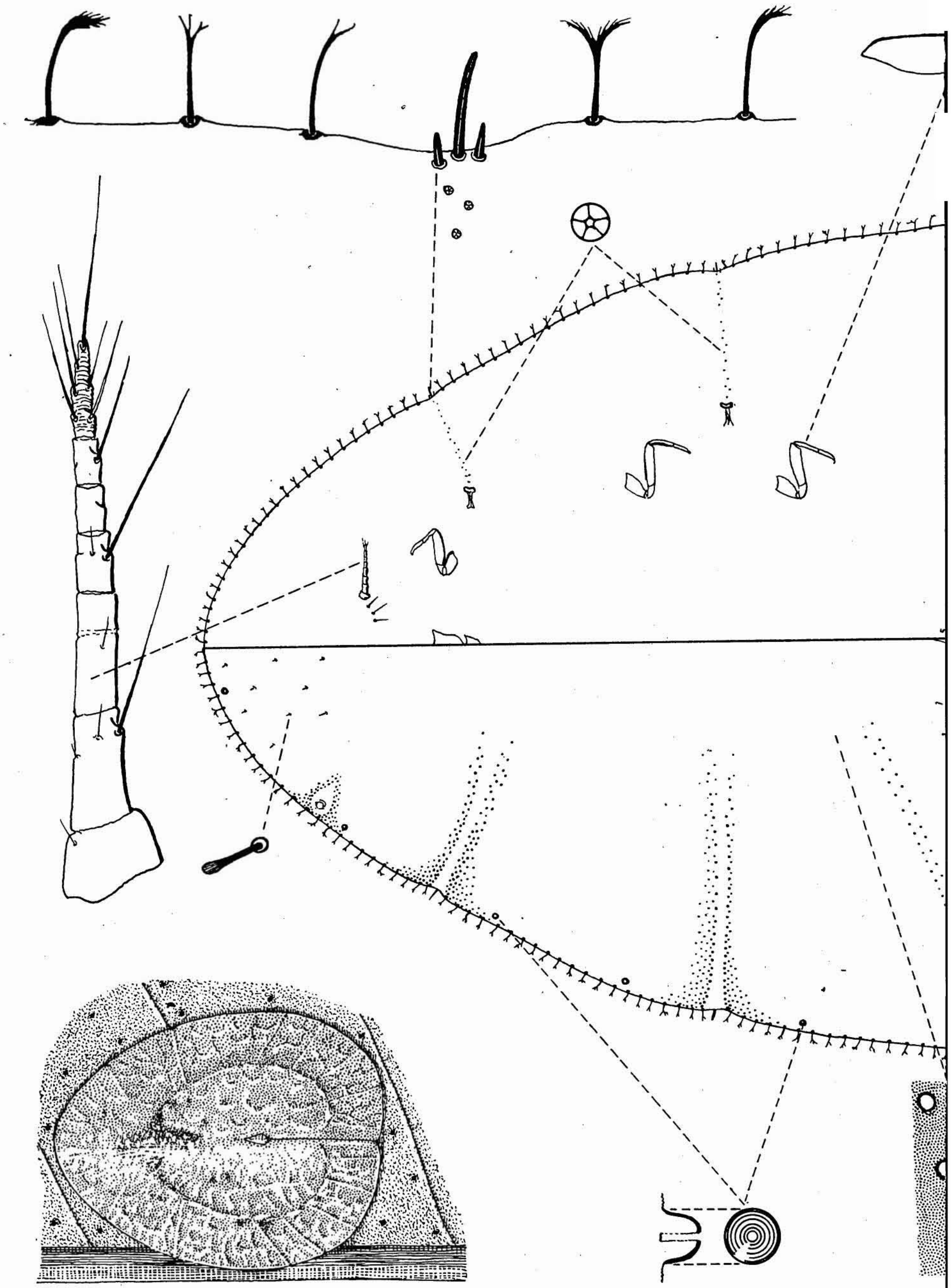
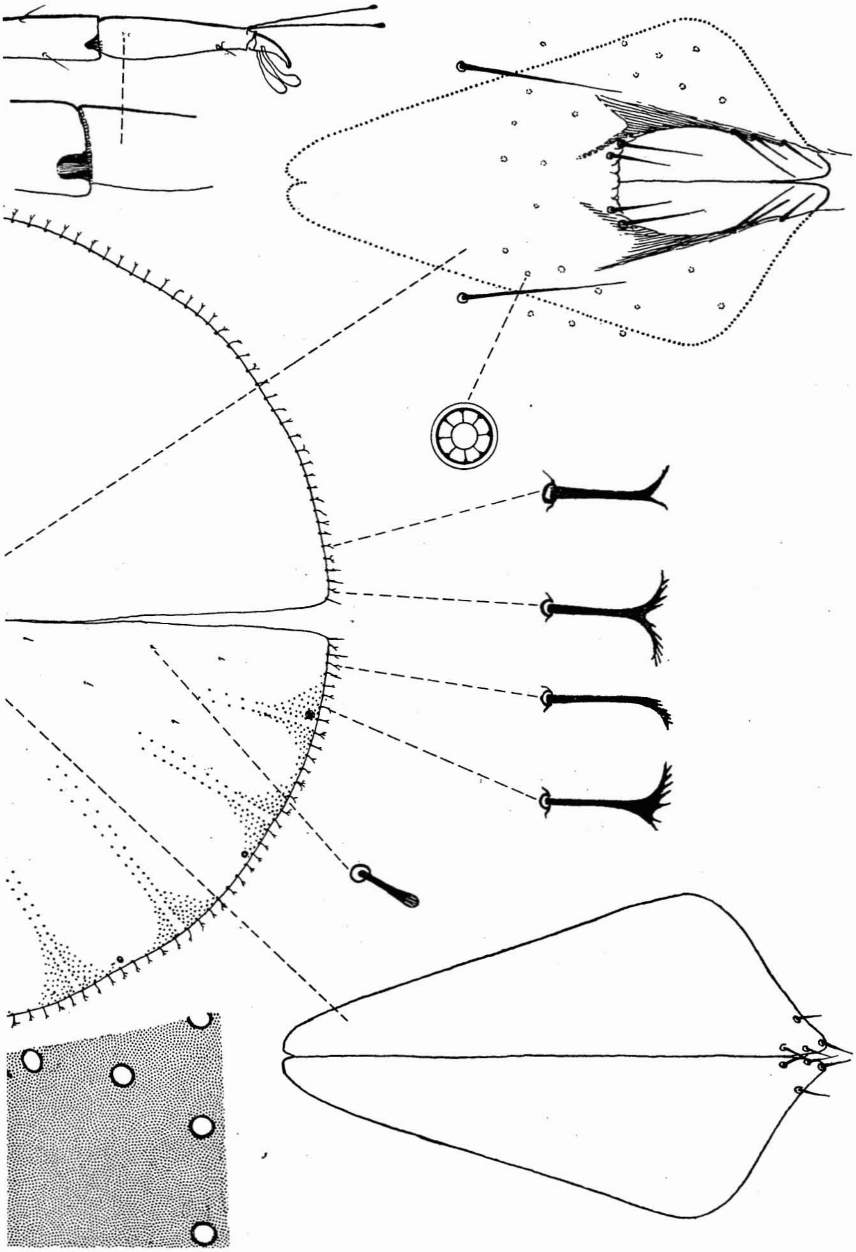


Figure 159—*Coccus mangiferae* (Green). (Drawn by Ferris from Koebele material fro[m] Hawaii, number 1378.)



Coccus pseudohesperidum (Cockerell) (fig. 160).

Lecanium pseudohesperidum Cockerell, American Naturalist, 29:380, 1895 (Reference not seen).

Oahu.

Immigrant. A widespread species. The first use of this name in Hawaiian literature as far as I know was by Fullaway (*Proc. Hawaiian Ent. Soc.* 10(1):46, 1938).

Hostplants: *Laelia anceps*, "orchids," vanilla.

According to Fullaway (1938:46) this is a common pest of orchids in Hawaii.

Ferris has supplied the following data:

Hosts and distribution: Originally described from an orchid, *Cattleya* sp., in a greenhouse at Ottawa, Canada. Specimens are at hand collected by E. M. Ehrhorn in 1920 and 1921 from an orchid, *Laelia anceps*, Honolulu, Hawaii, and others from vanilla, Manoa Valley, collected by L. A. Whitney.

Habit: Attaining a length of nearly 5 mm. and broadly oval. At maturity brown, smooth and polished, slightly convex.

Recognition characters: Antennae quite short, variable in segmentation, some specimens seemingly but four-segmented, with third and fourth segments noticeably elongate, others with third segment more or less definitely divided and with distinct short fourth and fifth segments. Legs rather short and stout, tarsus and tibia about equal in length and with division between them but slightly indicated. Marginal setae all slender, none flattened or frayed at apex. Anal plates with anterior-lateral margin slightly longer than posterior-lateral, thus being very slightly elongate, all apical setae very small; with two long and two short fringe setae. Anal cleft fused. Dorsum of body tending to be quite strongly sclerotized at maturity, but this sclerotization irregular in specimens at hand. Anterior to anal plates there are two irregular rows or series of small, sclerotized disc pores with slightly dome-shaped centers, these two series leaving between them a narrow, median band that is without pores. Over remainder of dorsum are numerous minute pore-like, clear spots which are distributed in such a manner as to form a slight suggestion of a pattern. At full sclerotization dome-shaped pores can be distinguished only with difficulty from others. Submarginal region of dorsum at full sclerotization showing a band of irregular, clear areas. Dorsum with a very few extremely small, simple setae. On ventral side, about region below anal plates, are a few disc pores.

Notes: I do not know the origin of the identification of this species as *pseudohesperidum*, but the identification seems to have been confirmed by Morrison.

The specimens collected by Ehrhorn have been identified, presumably by him, as *Coccus aequale* (Newstead), a species that was described in 1917, from *Avicennia nitida* in British Guiana. Whether or not this identification has been published, I do not know. As far as can be determined from Newstead's quite good description, this species is identical with *pseudohesperidum*, even though it was recorded from a host other than an orchid.

The accompanying illustrations are based upon the specimens collected by Ehrhorn from *Laelia anceps*, at Honolulu.

Coccus viridis (Green) (fig. 161).

Lecanium viride Green, 1889:248, 1 fig.

The green scale.

Oahu, Molokai, Maui, Hawaii.

Immigrant. A nearly cosmopolitan species thought to be of Brazilian origin. It has been considered to have been first recorded from Hawaii by Kotinsky in 1905 (*Proc. Hawaiian Ent. Soc.* 1(1):32). However, it may have been taken earlier by Koebele.

Hostplants: cacao, celery, coffee, *Fitchia, Gardenia,* guava, *Ixora macrothyrsa,* lime, *Morinda citrifolia* ("noni"), orange, *Plumeria.*

Parasites: *Microterys kotinskyi* (Fullaway) (Hymenoptera: Encyrtidae); *Aneristus ceroplastae* Howard, *Prococcophagus orientalis* (Howard), *Coccophagus hawaiiensis* Timberlake, *Coccophagus ochraceus* Howard (Hymenoptera: Aphelinidae); *Scutellista cyanea* Motschulsky, *Tomocera californica* Howard (Hymenoptera: Miscogasteridae).

Predators: *Orcus chalybeus* (Boisduval), *Chilocorus circumdatus* (Schönherr), *Azya luteipes* Mulsant, *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae).

A fungus (*Entomophthora pseudococci* ?), introduced from Florida, also does good work in aiding in its control in humid regions.

This species was at one time (1910) believed to have been exterminated, but it is still with us and has been a pest for many years. It is believed that it was imported from Fiji.

Some local workers have confused *Pulvinaria psidii* with this species, but the two can be separated easily. *Pulvinaria* produces a cottony ovisac, but *Coccus* does not.

Illingworth (*Proc. Hawaiian Ent. Soc.* 10(1):3, 1938) reported that "It is a difficult pest to control with ordinary oil-emulsion sprays. An atomized Deo-Base oil to which pyrethrum extract had been added gave perfect control with no injury to the foliage." Carter has obtained complete control by using a 2 percent Diesel oil–bentonite emulsion.

The following notes are by Ferris:

Habit: According to descriptions of the species, it occurs mostly on leaves and in life is a bright, pale green. In dried specimens it becomes very pale except for dark areas of internal pigmentation. Oval, very flat; dried specimens irregularly wrinkled.

Recognition characters: Length on slide about 2.0–2.5 mm. Derm membranous at full maturity, or at most with a faint sclerotization that appears in well-stained specimens. In such specimens derm very sparsely areolated, each areolation with a minute median pore of indeterminate character. Marginal setae extremely small, of various shapes, some simple but majority slightly fimbriate at apex. Anal plates almost quadrate, apical setae extremely minute, ventral fold with but four fringe setae. On ventral side, about area below anal plates and vulva, are numbers of multilocular pores, and a few such pores forward as far as posterior coxae. In

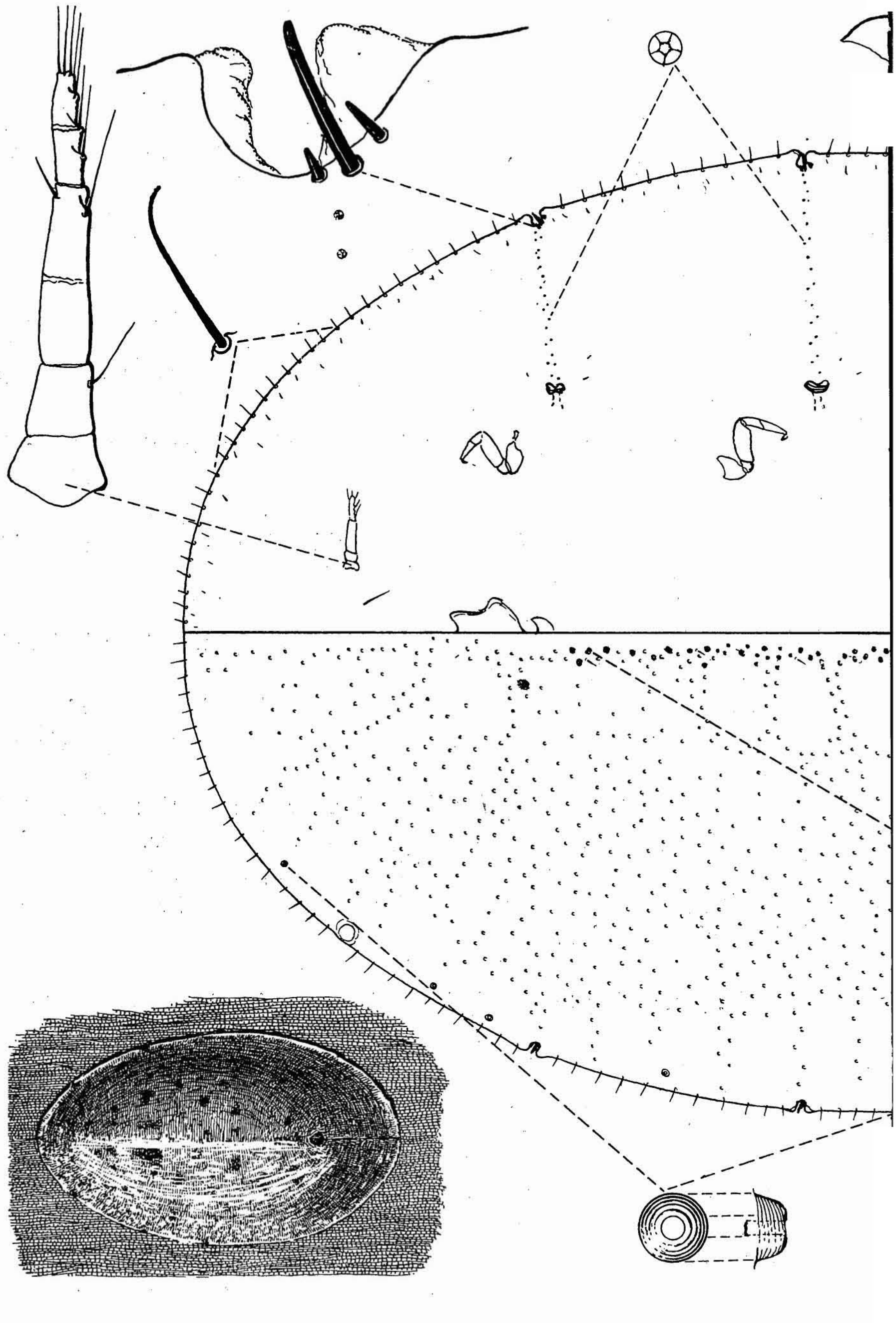
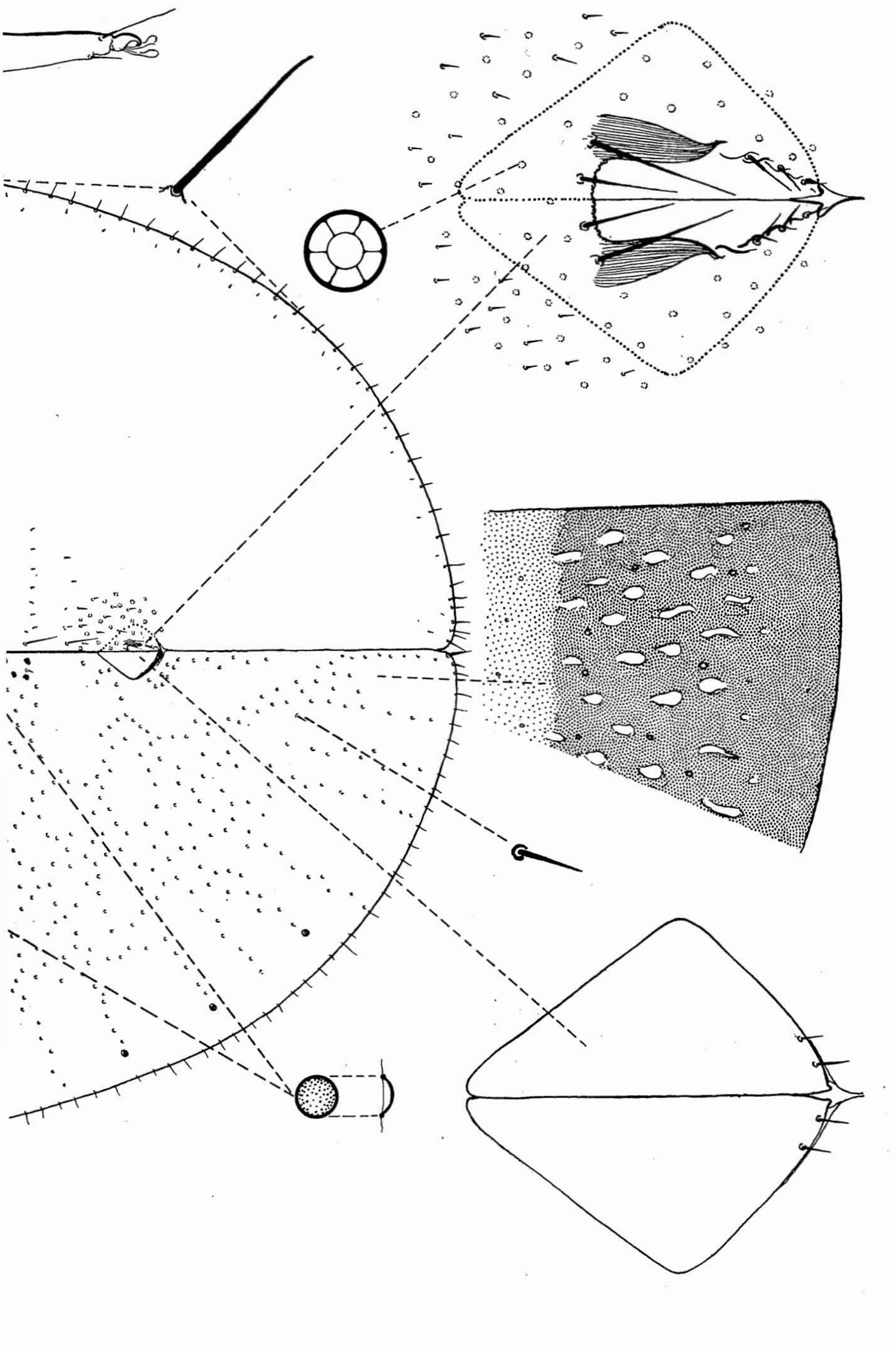


Figure 160—*Coccus pseudohesperidum* (Cockerell). (Drawn by Ferris from materi
Laelia anceps from Honolulu.)



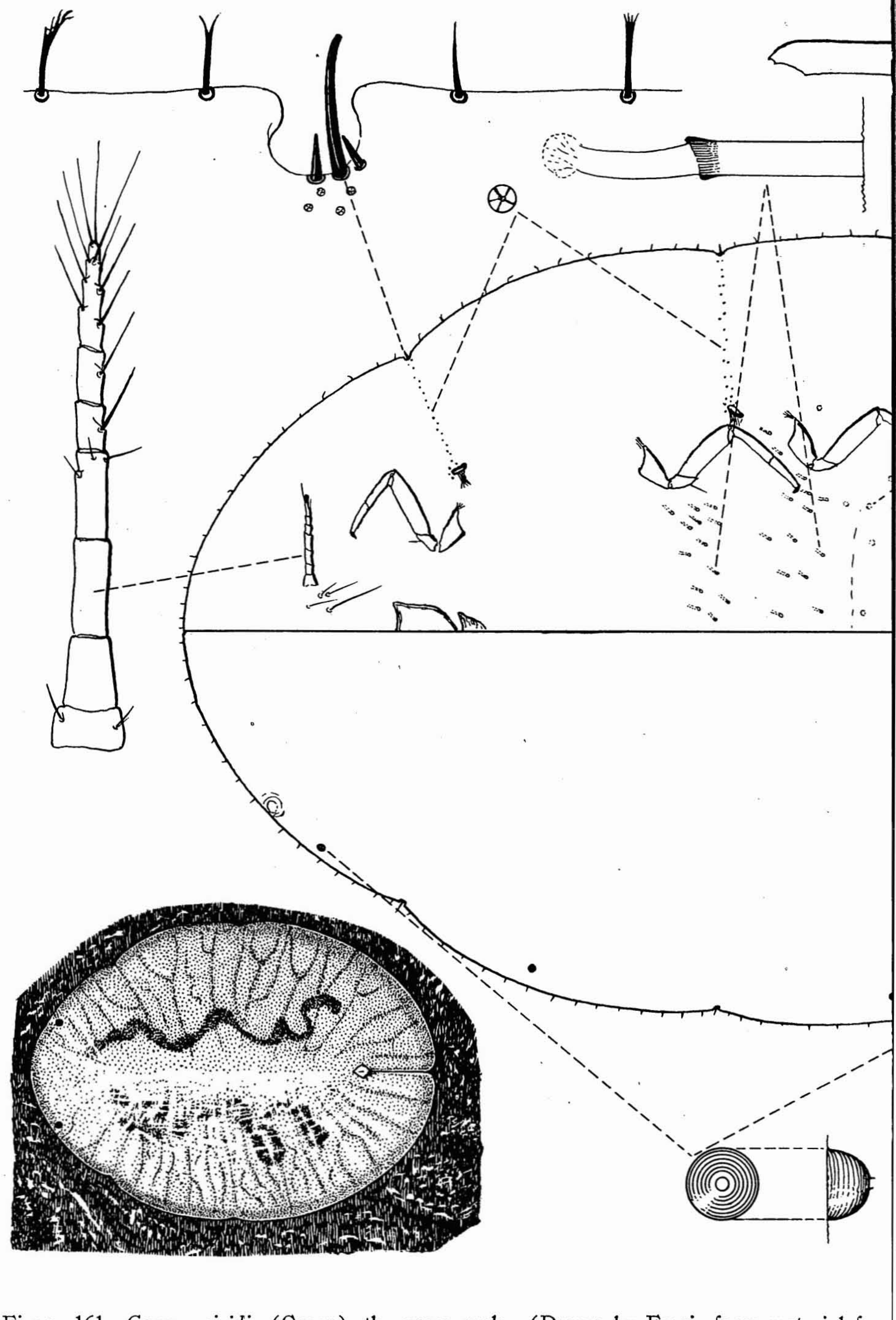
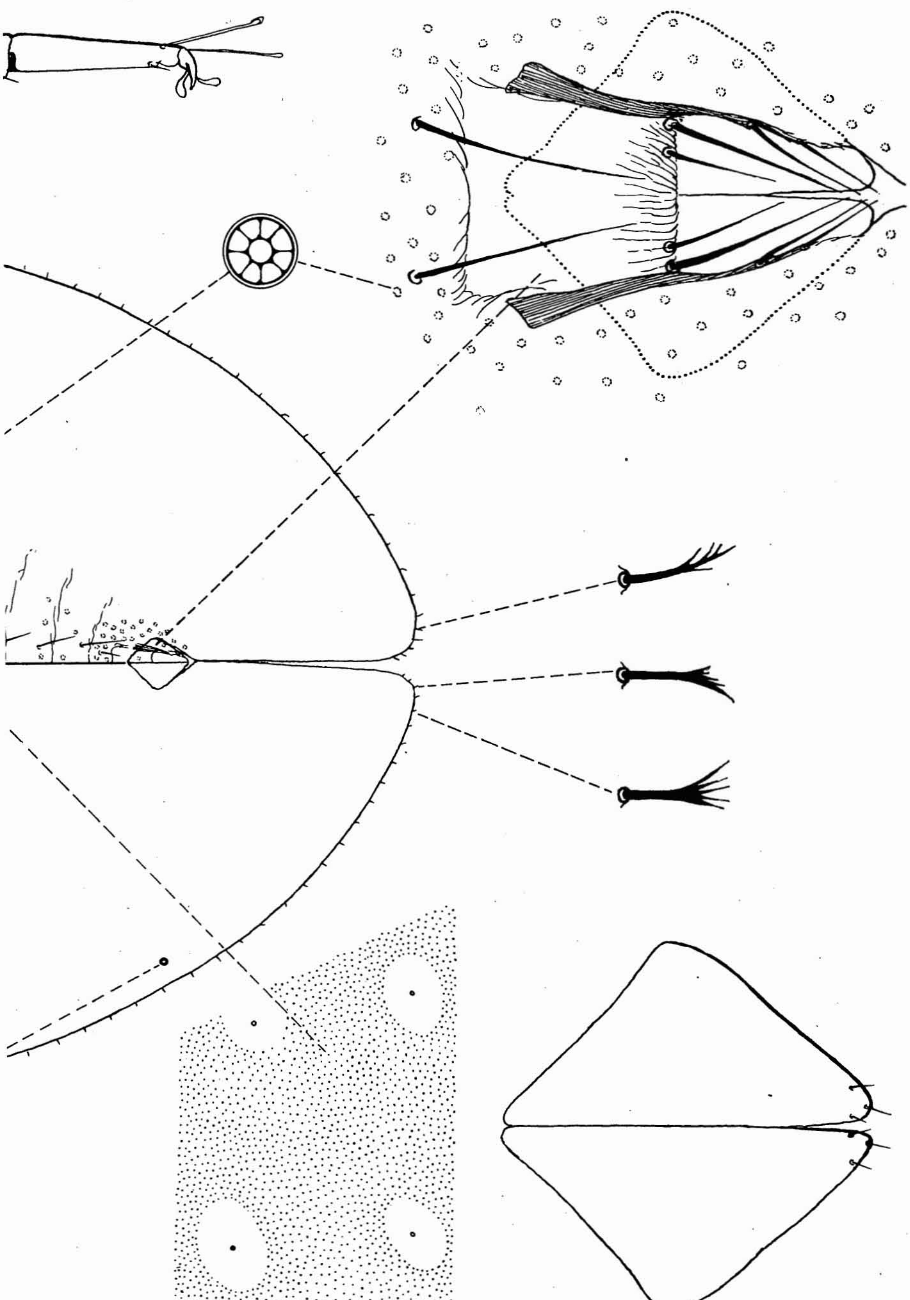


Figure 161—*Coccus viridis* (Green), the green scale. (Drawn by Ferris from material fron *Loranthus tomentosus* from Ceylon.)



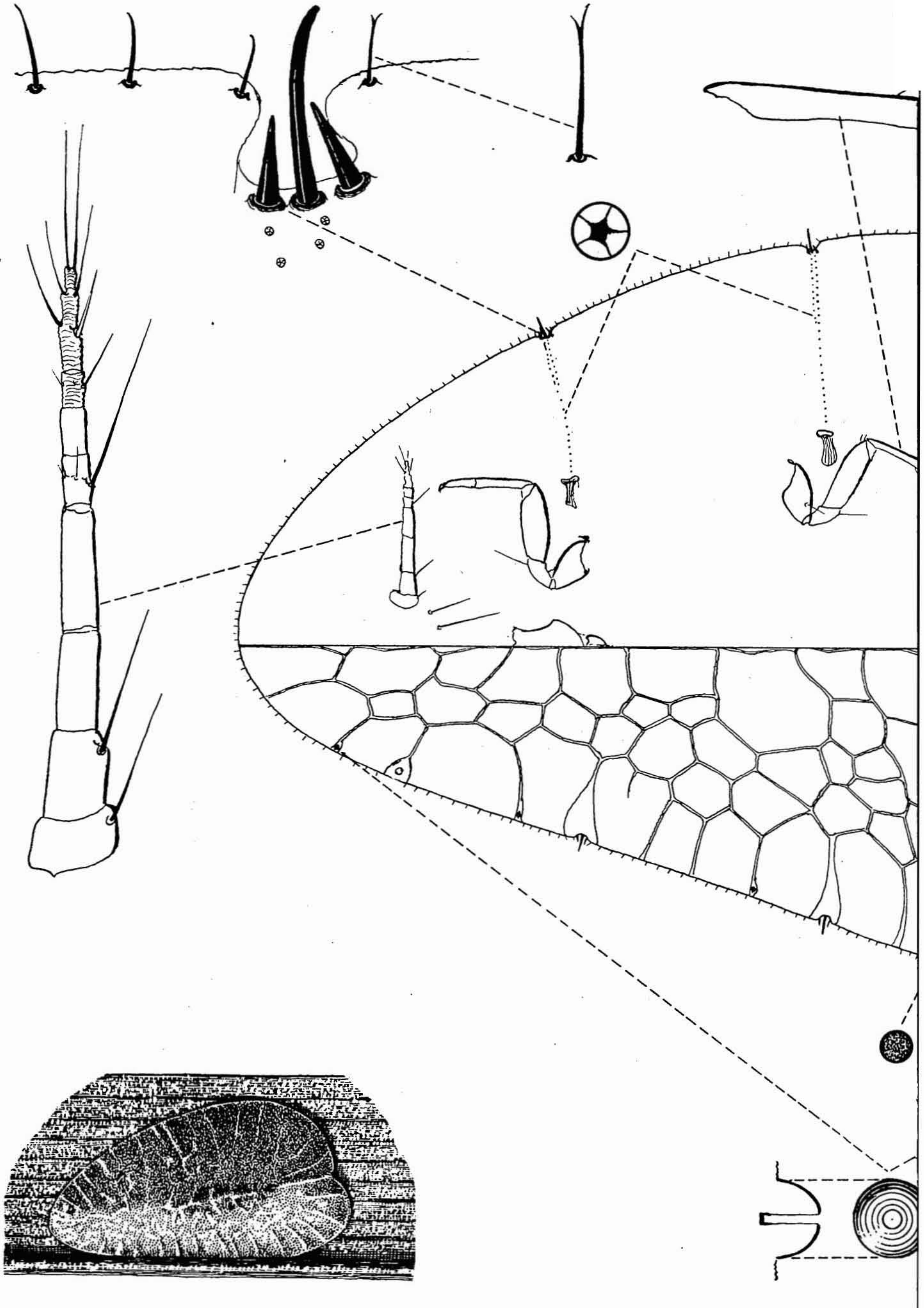
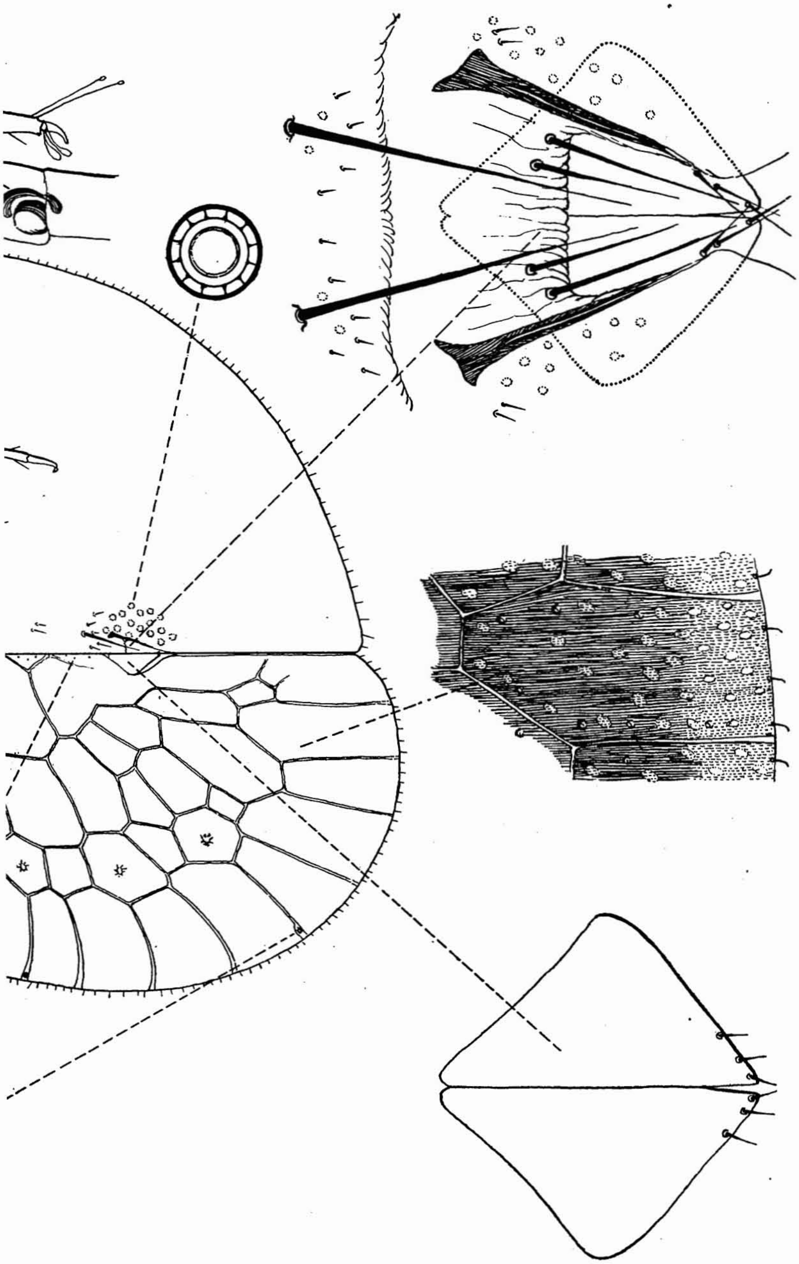


Figure 162—*Eucalymnatus tessellatus* (Signoret), the tessellated scale. (Drawn by Ferri[s] from material from palm from Ceylon.)



median area between middle and posterior coxae are a few tubular ducts. Antennae well developed, slender, normally seven-segmented. Legs well developed, presenting no unusual characters.

Notes: The very minute, apically fimbriate marginal setae, combined with presence of multilocular pores as far forward as posterior coxae, and presence of tubular ducts in median area between middle and posterior coxae seem to be distinctive of the species.

The accompanying illustrations are based upon specimens from *Loranthus tomentosus,* Pundaluoya, Ceylon, received from E. E. Green.

Genus **EUCALYMNATUS** Cockerell, 1901:57

We have only one representative of this group in the Hawaiian Islands, but others are known elsewhere. The conspicuous plate-like divisions of the derm of the dorsum are characteristic of the adult female.

This genus is based solely upon the fact that the sclerotized derm of the dorsum is divided into a pattern of relatively large plates. Except for this feature it is, in all morphological characters, indistinguishable from *Coccus* as the latter genus is represented by its type, *Coccus hesperidum* Linnaeus. Only extensive studies can demonstrate whether the genus can be maintained. (Ferris.)

Steinweden (1929:224) states that "I have studied several young adult females before the hardening and tessellating of the derm had begun and when the structural characters could be clearly seen. I see no reason for maintaining the genus as distinct from *Coccus* or at the most as anything more than a subgenus."

Eucalymnatus tessellatus (Signoret) (figs. 162, 163).
Lecanium tessellatum Signoret, 1873:401, pl. 12, fig. 4.
Lecanium (*Eucalymnatus*) *tessellatus* (Signoret) Cockerell, 1901:57.
Coccus tessellatus (Signoret), Steinweden, 1929:224.
Sanders, 1909:435, pl. 20, fig. 1.

The tessellated scale.

Kauai, Oahu, Maui.

Immigrant. A nearly cosmopolitan species; first noted in the Territory by Craw in 1896 (p. 40).

Hostplants: coconut, cinnamon, *Elaeocarpus,* ferns, palms.

Parasites: *Anicetus annulatus* Timberlake (Hymenoptera: Encyrtidae); *Coccophagus* sp. (Hymenoptera, Aphelinidae).

Ferris supplies the following notes:

Habit: Occurring on leaves, usually lying with one side pressed against a vein and thus becoming asymmetrical; sometimes, however, regularly oval. Very flat; color very dark brown.

Recognition characters: Length at maturity as much as 5 mm. The sclerotized

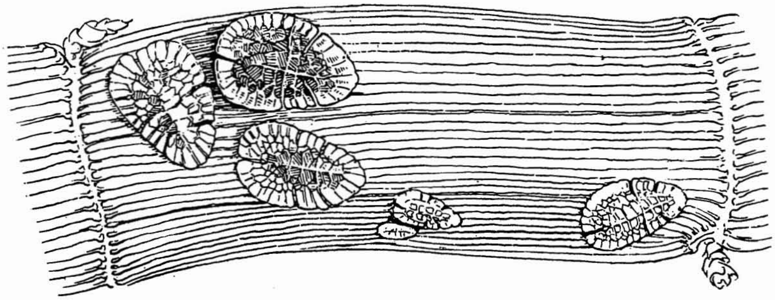


Figure 163—*Eucalymnatus tessellatus* (Signoret), the tessellated scale. (Abernathy drawing.)

dorsal derm is divided by narrow membranous furrows into a complicated pattern of large plates, which have a definite arrangement as indicated in accompanying figure. The sclerotized derm shows a pattern of scattered, puncture-like, small pores and some mottling with small, ill-defined, oval, clear areas. Marginal setae very small, slender, occasionally bifid apically. Just in front of anal plates is a small cluster of very small disc pores with a granular center. Submarginal tubercles present. Anal plates quadrate, their combined width as great as, or slightly greater than, their length. On ventral side of abdomen there is a small cluster of multilocular disc pores about base of anal cleft and region of vulva. Fold at entrance to anal invagination bears four fringe setae. Apparently no tubular ducts present. Antennae normally seven-segmented. Legs with tibio-tarsal articulation apparently not free, but with a quite large tibio-tarsal articulatory sclerosis.

Notes: In specimens taken before the sclerotization of the dorsal derm, the only distinctive features separating this species from others, such as *Coccus hesperidum*, are the definitely quadrate anal plates. However, the tessellation of the derm begins to appear very early in the last instar and this is immediately distinctive.

Genus **SAISSETIA** Déplanche, 1858

It is difficult, in the present state of our knowledge, to give a characterization of this genus that means very much. The three species known to occur in Hawaii and which are conventionally referred to this genus agree in having the dorsal derm very strongly sclerotized at full maturity, and in having the body moderately convex or very strongly so. In the type of the genus, *hemisphaerica*, the sclerotized dorsal derm is marked with numerous, small, oval, clear areas, each of which surrounds a minute pore. In the other two species the pattern of markings is more complex, the clear areas around the pores being very small and in turn being surrounded by a slightly sclerotized area, these areas being then separated from each other by narrow bands of deep sclerotization. Dorsal wax secretion is at the most in the form of minute lumps or thin scales which disappear in weathered specimens. In two of the species the anal plates each bear a large, discal seta, the socket of which can be seen even if the seta itself is lost, but this seta is not

present in *nigra*. Legs and antennae well developed, the legs with either flexible or non-flexible tibio-tarsal articulation. Marginal setae of various forms, but tending to be slender and quite long and variously fimbriate at the apex. Tubular ducts present at least in a broad submarginal band on the venter, this band extending entirely around the body. In one species, *nigra,* these ducts are extremely obscure, but they can be seen in properly prepared specimens.

Mature specimens of *nigra* can be referred to this genus on the basis of the polygonally reticulate dorsal derm, but unsclerotized individuals can be separated from *Coccus* only by the presence of the very minute tubular ducts which can very easily be overlooked.

Key to the Species of Saissetia Reported from Hawaii

1. At full maturity oval and but slightly convex or elongate and moderately convex, dark brown or black; derm of dorsum polygonally reticulate; anal plates without a discal seta; tibio-tarsal articulation not free; tubular ducts present in a submarginal, ventral zone, but excessively small and of but one size; fringe setae below the anal plate normally four.................................... **nigra** (Nietner).
   At full maturity high convex, normally circular in outline; anal plates each with a large discal seta.................. 2
2. At full maturity light brown, derm smooth, with numerous, small, oval or circular, clear areas; in unsclerotized specimens zone of ventral tubular ducts contains ducts of two distinct sizes and shapes, the larger having apical filament as broad as basal tube...... **hemisphaerica** (Targioni-Tozzetti).
   At full maturity very dark, derm slightly rugose and normally with transverse and longitudinal ridges forming an H-shaped figure; in unsclerotized specimens the zone of ventral tubular ducts is composed of ducts of but one size and shape, these with a slender apical filament...............
   .... **oleae** (Bernard).

The above material on *Saissetia* was prepared by Ferris.

Saissetia hemisphaerica (Targioni-Tozzetti) (figs. 164, 165).

Lecanium hemisphaericum Targioni-Tozzetti, 1867:26.
Lecanium coffeae, of Koebele, 1898:112.
Coccus coffeae, of Kirkaldy, 1902:105.
Sanders, 1909:439, pl. 19, fig. 16; pl. 20, fig. 4.

The hemispherical scale.

Oahu, Maui, and probably the other islands.

Immigrant. A cosmopolitan pest. The first record of the species in the Territory appears to be that of Koebele (1898:112).

Hostplants: *Clermontia parviflora, Cyrtomium* fern, "ferns," *Pipturus, Solanum sanitwongsei,* etc.

Parasites: *Encyrtus infelix* (Embleton), *Encyrtus barbatus* Timberlake, *Microterys flavus* (Howard) (Hymenoptera: Encyrtidae); *Tomocera californica* Howard, *Scutellista cyanea* Motschulsky (Hymenoptera: Miscogasteridae); *Aneristus ceroplastae* Howard (Hymenoptera: Aphelinidae).

This is a polished pale to dark-brown species (female, when mature) which lays creamy white eggs and may be found on a wide range of hostplants, a detailed list of which has not been assembled for Hawaii.

Ferris has supplied the following notes:

Habit: Occurring either on small stems or leaves; form varying somewhat in correlation with position. On flat surfaces body may be almost hemispherical, while on small stems it may be somewhat elongate. The size also varies greatly, even on same individual hostplant. At maturity, however, there is a characteristic appearance, the body being high-convex, derm smooth and polished and of a yellow-brown color.

Recognition characters: In specimens taken in last instar, but while derm is still membranous, the following characteristics appear: Length 1.5 to 3.0 mm. Dorsal derm with numerous, exceedingly minute, round pores; with a few—scarcely more than 10—very small, tubercle-like pores in region anterior to anal plates; with rather numerous, but exceedingly small, pointed setae scattered irregularly. Submarginal tubercles present, variable in number. Anal plates together about as wide as long, individual plates with anterior-lateral margin somewhat shorter than posterior-lateral margin; each with a large, stiff, apically simple or slightly fimbriate discal or sub-discal seta. If this seta is broken off, as it frequently is, the large socket is evident. Marginal setae variable in length, but for most part quite long and slender, apex either simple or slightly flattened and variously fimbriate; proportion of simple and fimbriate setae seems to be variable, even in specimens from same lot. On ventral side, there are two groups of three or four setae of various lengths along margin of lip of anal invagination. Multilocular disc pores present in numbers about base of anal cleft and appear in rows on all abdominal segments, with a few even about posterior coxae. Great numbers of tubular ducts present, these being of two distinct sizes. The larger ducts appear in a broad, submarginal zone that extends from near anal cleft to head, being interrupted only by stigmatic furrows. These ducts quite sclerotized and apical filament nearly as long and as broad as basal portion. Other ducts much smaller and have apical filament slender. These ducts appear on both sides of zone of larger ducts and are present in small numbers in median region of abdomen. Antennae quite slender, normally eight-segmented. Legs with movable tibio-tarsal articulation, tibia with an articulatory sclerosis.

At full maturity derm of dorsum becomes thickened and quite strongly sclerotized. Each of the minute dorsal pores is surrounded by a circular or oval, pale area, which represents a thin place in derm. In an unmounted specimen these areas may be seen under a relatively low magnification of the dissecting microscope, appearing as little, yellow spots.

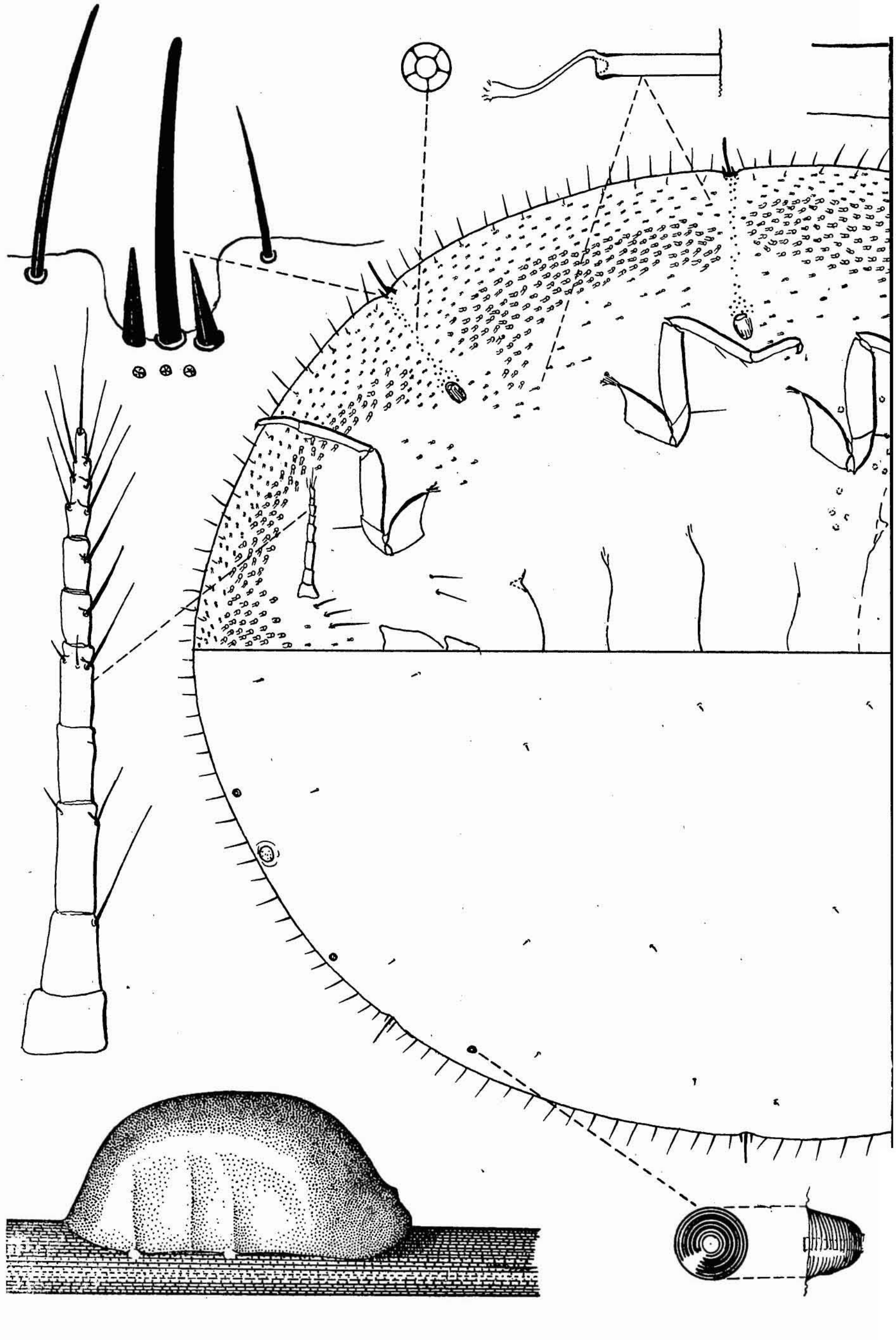


Figure 164—*Saissetia hemisphaerica* (Targioni-Tozzetti), the hemispherical scale. (Drawn by Ferris.)

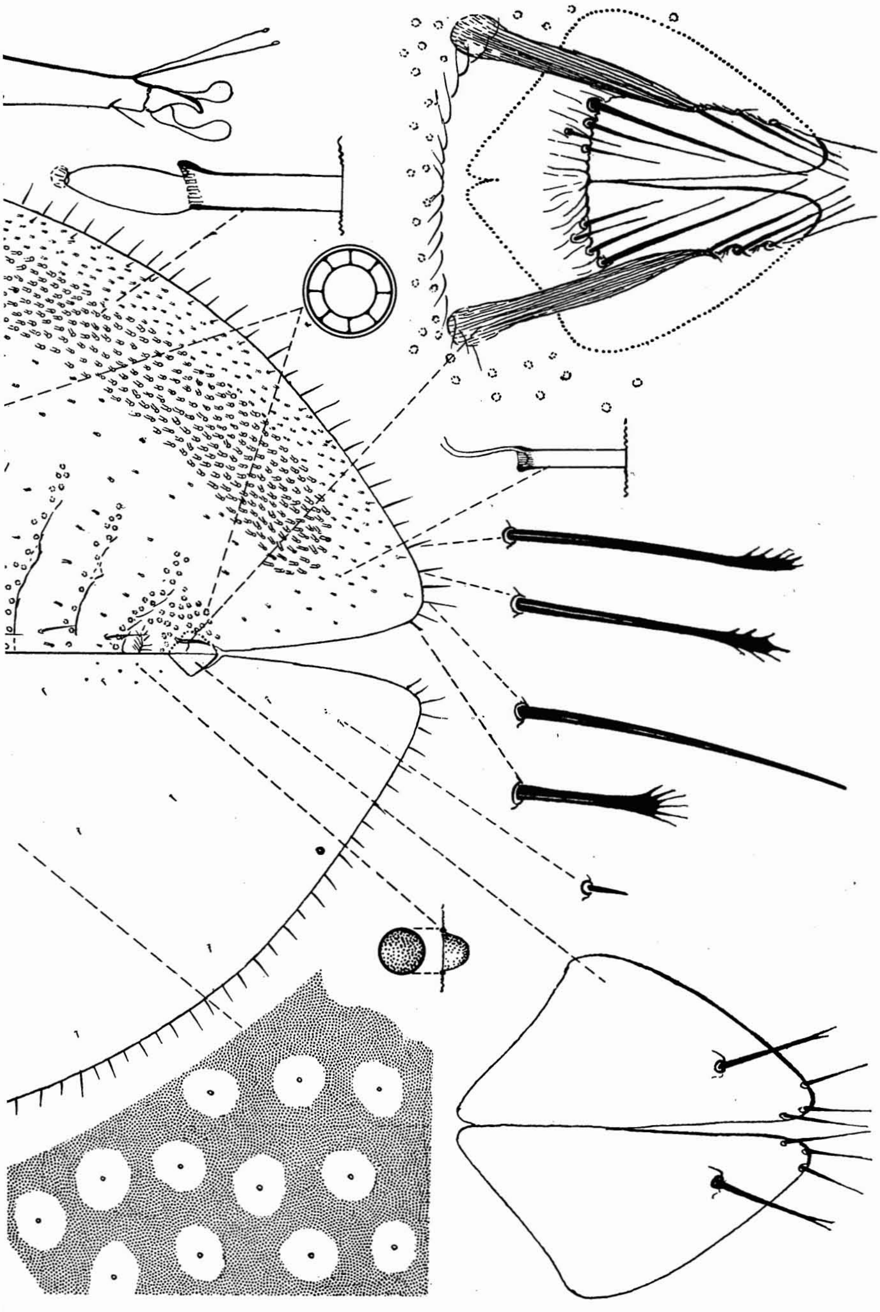


Figure 165—*Saissetia hemisphaerica* (Targioni-Tozzetti) on a stem of *Epidendrum.*

Notes: Structurally, this species is very close to *oleae,* although the two are easily separable in adult specimens. The two species differ most sharply because in *hemisphaerica* the ducts in the ventral zone are of two sizes, the larger ducts having the apical filament nearly or quite as broad as the basal tube. These ducts can be seen very easily in any good preparation.

The accompanying illustrations are based upon specimens from fern in a greenhouse at Stanford University, California.

Saissetia nigra (Nietner) (figs. 166, 167).

Lecanium nigrum Nietner, "Observations on the Enemies of the Coffee-tree in Ceylon," Ceylon Times, p. 9, 1861 (I have not seen this reference).

Sanders, 1909:440, pl. 20, fig. 3.

The nigra scale.

Oahu, Molokai, Maui, Hawaii, Laysan.

Immigrant. A nearly cosmopolitan pest species. First recorded in Hawaii by Maskell in 1895 (p. 16).

Hostplants: *Abutilon molle, Alpinia purpurata, Anthurium,* bamboo, *Bougainvillea, Brassaia actinophylla polymorpha, Codiaeum variegatum* (croton), cotton, *Emex spinosa, Ficus,* fig, *Gossypium tomentosum,* guava, *Hibiscus, Ipomoea tuberosa, Metrosideros, Moraea bicolor,* nutgrass, pineapple, *Santalum paniculatum, Smilax, Zingiber.*

Parasites: *Microterys flavus* (Howard), *Microterys kotinskyi* (Fullaway), *Encyrtus infelix* (Embleton), *Encyrtus barbatus* Timberlake (Hymenoptera: Encyrtidae); *Tomocera californica* Howard, *Scutellista cyanea* Motschulsky (Hymenoptera: Miscogasteridae); *Coccophagus hawaiiensis* Timberlake, *aneristus ceroplastae*

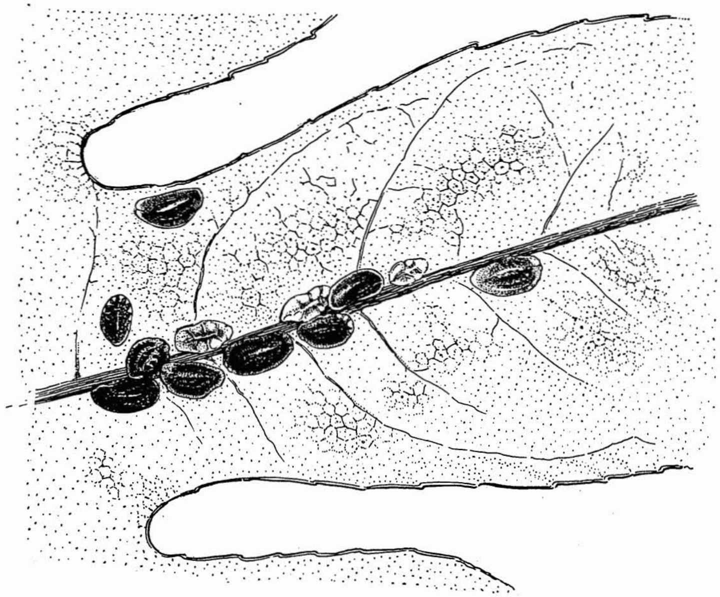


Figure 166—*Saissetia nigra* (Nietner). (Abernathy drawing.)

Howard (Hymenoptera: Aphelinidae). Also attacked by a fungus, probably *Entomophthora pseudococci.*

The following summation is by Ferris:

Habit: Occurring on leaves or on twigs that contain chlorophyll. On leaves, the scales are usually rather broadly oval and only moderately convex; on twigs they tend to become narrow, elongate and relatively high convex. In mature specimens color varies from dark brown to shiny black. Surface smooth, unweathered adult specimens showing delicate, flat plates of wax arranged more or less in rows.

Recognition characters: Length as much as 5 mm., but usually less. In adult specimens taken before derm has become sclerotized, dorsum devoid of structures other than numerous exceedingly minute circular pores; a few scattered and exceedingly minute setae; and a group of ten or more circular disc pores with a slightly dome-shaped center, just anterior to anal plates. At full maturity, after sclerotization is complete, dorsal derm marked by polygonal areas, each of which is formed about one of the minute pores, there being, however, a narrow marginal band, extending entirely around body that is not thus reticulated. Anal plates together almost as wide as long, anterior-lateral margin of each being somewhat shorter than posterior-lateral margin; no discal seta is present. Marginal setae moderately long, slender, for most part with apex flattened and expanded, clavate or variously fimbriate. Submarginal tubercles present, variable in number. Ventral side of abdomen with a cluster of multilocular disc pores about base of anal cleft and anterior to vulva, and with a few such pores on each abdominal segment. Tubular ducts present only in a submarginal zone which extends entirely around body, these ducts extremely small and delicate, all of a single size and shape and

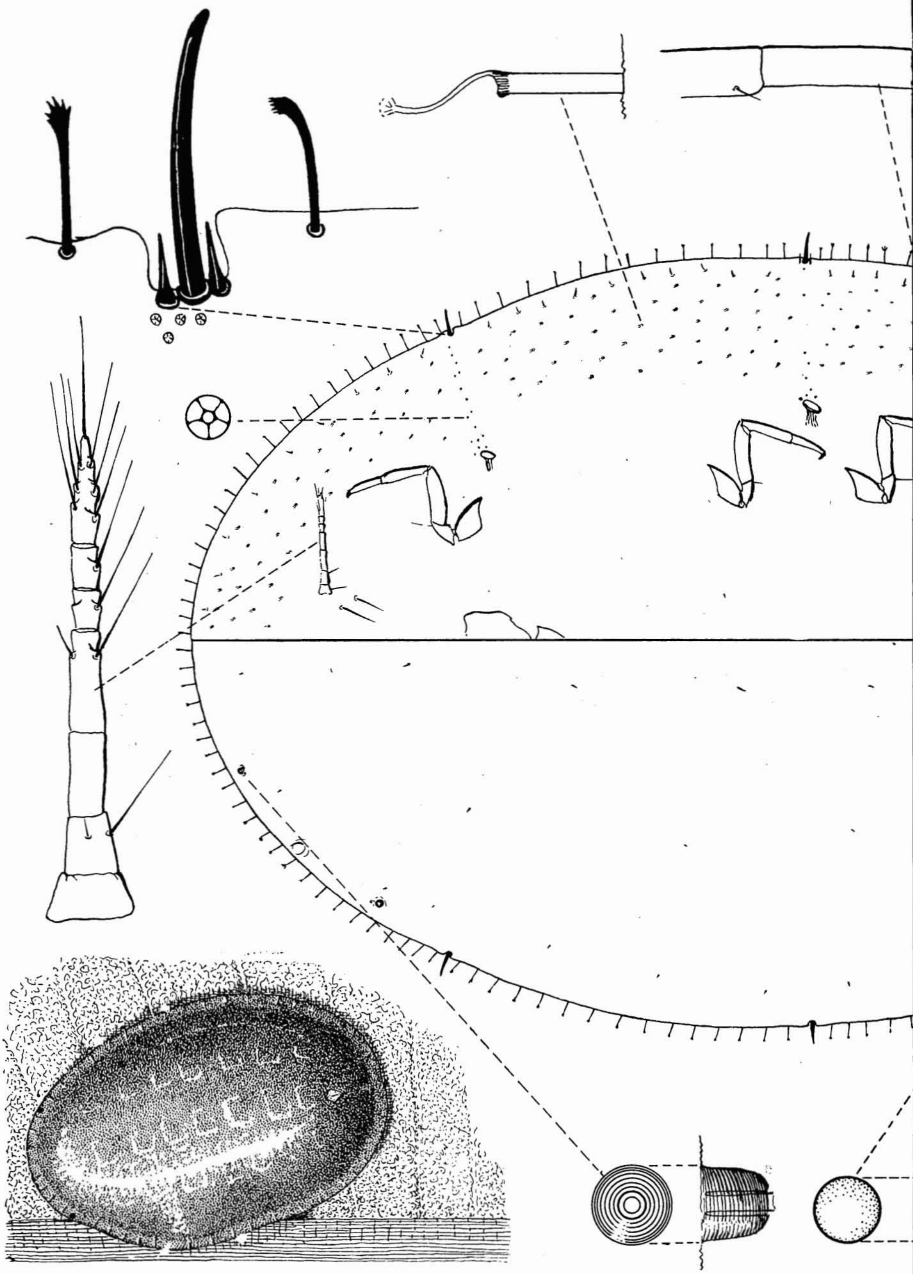
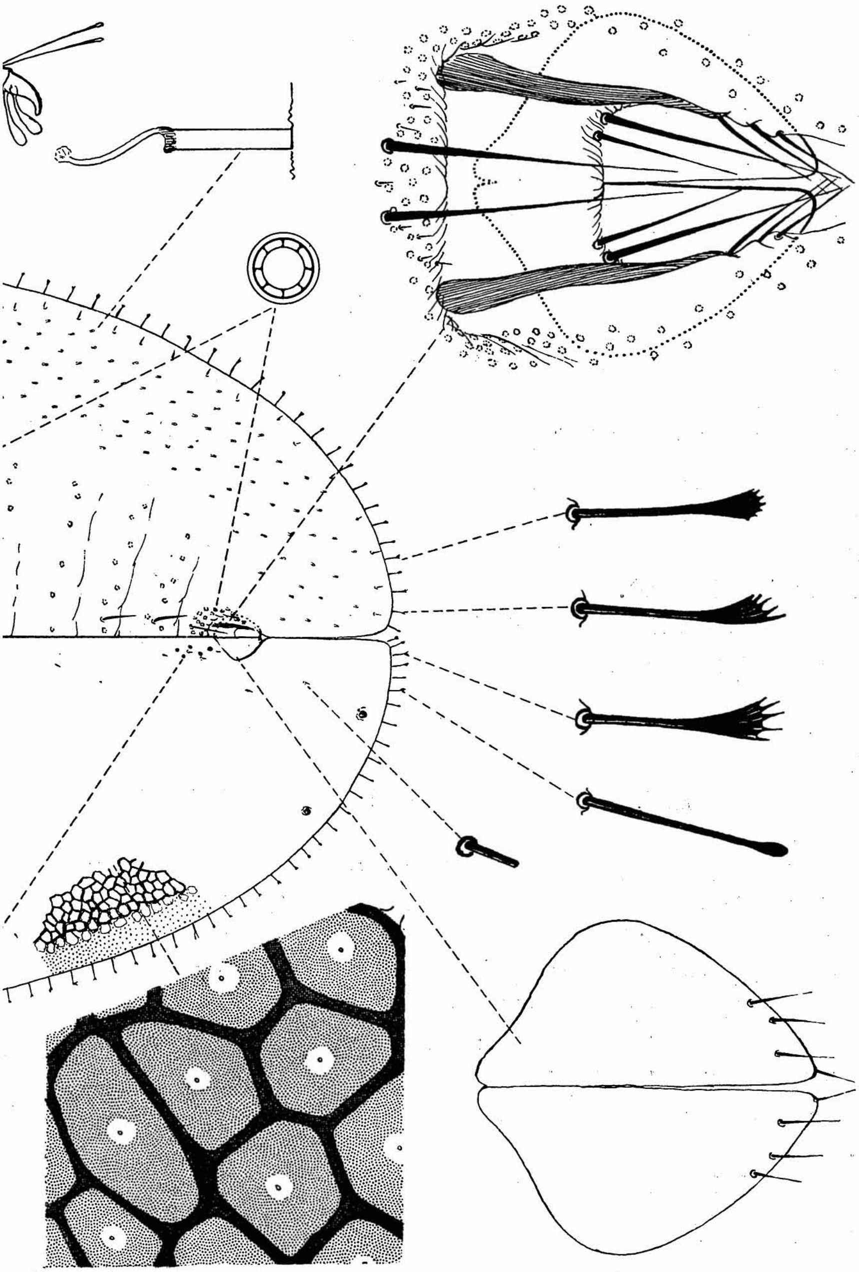


Figure 167—*Saissetia nigra* (Nietner), the nigra scale. (Drawn by Ferris.)



with a narrow apical filament. These ducts are so obscure that they can be seen only in well-prepared and favorable specimens, but they are definitely present. There seem normally to be but two setae in each group of fringe setae on fold formed by invagination of anal ring. Antennae seven- or eight-segmented. Legs with base of tarsus as broad as apex of tibia, the joint being a simple line and apparently non-flexible; tarsus without an articulatory sclerosis.

Notes: There is considerable variation in size, form and color of the mature female and in size and form of the marginal setae, so much so as to suggest the possibility that more than one species passes under this specific name. However, these variations are to be seen in specimens taken from the same twig at the same time, and no satisfactory basis appears for the recognition of more than one species.

Specimens from Hawaii on undetermined host have been seen in connection with this work. The accompanying illustrations are based on specimens from *Nerium*, Stanford University, California.

Saissetia oleae (Bernard) (fig. 168).

Lecanium oleae Bernard, Mem. d'Hist. Nat. Acad. Marseille, p. 108, 1782 (I have not seen this reference).

Coccus oleae (Bernard), Kirkaldy, 1902:106.

Sanders, 1909:440, pl. 20, fig. 2.

The black scale.

Oahu, Maui.

Immigrant. Nearly cosmopolitan. First listed from Hawaii by Maskell in 1895 (p. 16).

Hostplants: "akala" berry (native *Rubus*), *Calotropis gigantea, Ceara* rubber, *Citrus,* cotton, *Crotalaria,* croton, guava, oleander, *Santalum haleakalae,* sisal.

Parasites: *Aphycus lounsburyi* (Howard) (Hymenoptera: Encyrtidae); *Aphytis chrysomphali* (Mercet), *Aneristus ceroplastae* Howard, *Marietta carnesi* (Howard), *Coccophagus* sp. (Hymenoptera: Aphelinidae); *Scutellista cyanea* Motschulsky, *Tomocera californica* Howard (Hymenoptera: Miscogasteridae).

Predators: *Lindorus lophanthae* (Blaisdell) [*Rhizobius ventralis* (Erichson) in literature], *Orcus chalybeus* (Boisduval), *Olla abdominalis* (Say) (Coleoptera: Coccinellidae).

The females are dark brown or black and have a characteristic H-shaped elevated mark on the dorsum. Several thousand yellowish brown eggs may be laid by one female. This is one of the most economically important of all scale insects. Essig (1929:299) reported that it has caused losses of more than two million dollars a year to California fruit growers. We do not have much trouble with it in Hawaii, however.

Ferris' notes follow.

Habit: Occurring either on leaves or woody parts of host. At maturity adult female very high convex and roughly circular or broadly oval in outline; dorsum with two transverse ridges connected by a median ridge, thus forming the H-shaped mark which is rather characteristic of this species. Color at maturity black or very dark brown, surface slightly rugose and beset, in unweathered specimens, with minute lumps of white wax. At full maturity dorsal derm very strongly sclerotized. In last instar, before sclerotization of derm has begun, color may be gray or slightly pink.

Recognition characters: Length of fully mature, unmounted individuals about 3 mm., or slightly more. Specimens in last instar, taken before sclerotization of derm has begun, show dorsum beset with numerous, very small, circular pores; with a few, small, scattered, conical setae; with a cluster of as many as 30, quite large, circular pores with thick rim and slightly dome-shaped center in median region just anterior to anal plates. At full maturity, after sclerotization, dorsal derm marked throughout with polygonal areas, each surrounding one of the little, circular pores. The varying pigmentation of each of these areas corresponds to differences in thickness of derm, as shown in sections. Marginal setae all slender, of somewhat variable length, longest being half or more as long as longest of stigmatic setae, some apically simple but most with apex slightly flattened and slightly fimbriate or branched. Anal plates slightly longer than their combined width, anterior-lateral margin of each being slightly shorter than posterior-lateral margin, each plate with a quite long, apically simple or slightly fimbriate discal seta. Submarginal tubercles present, variable in number.

On ventral side of body numerous multilocular pores are present in a cluster about base of anal cleft and vulva and a sparse row of these pores is present across median region of each abdominal segment. Tubular ducts are numerous, but confined to a broad submarginal zone that extends from borders of anal cleft to head, ducts all quite small and with a narrow, terminal filament. Antennae eight-segmented. Legs with apex of tibia no wider than base of tarsus; articulatory process of tarsus very small.

Notes: Morphologically this species is very close to *S. hemisphaerica,* although the two differ in numerous small details, such as the size of the median disc pores anterior to the anal plates and the size of the small dorsal setae, all these being larger than in *hemisphaerica.* The most positive key character for the separation of early last instar specimens is the presence in *oleae* of tubular ducts which are all of but one size and which have the apical filament narrow, as contrasted with the two sizes present in *hemisphaerica,* of which the larger ducts have the apical filament nearly as wide as the basal portion. In sclerotized specimens the polygonal markings of the dorsal derm will separate these two species immediately.

The accompanying illustrations are based on specimens from *Nerium,* Stanford University, California.

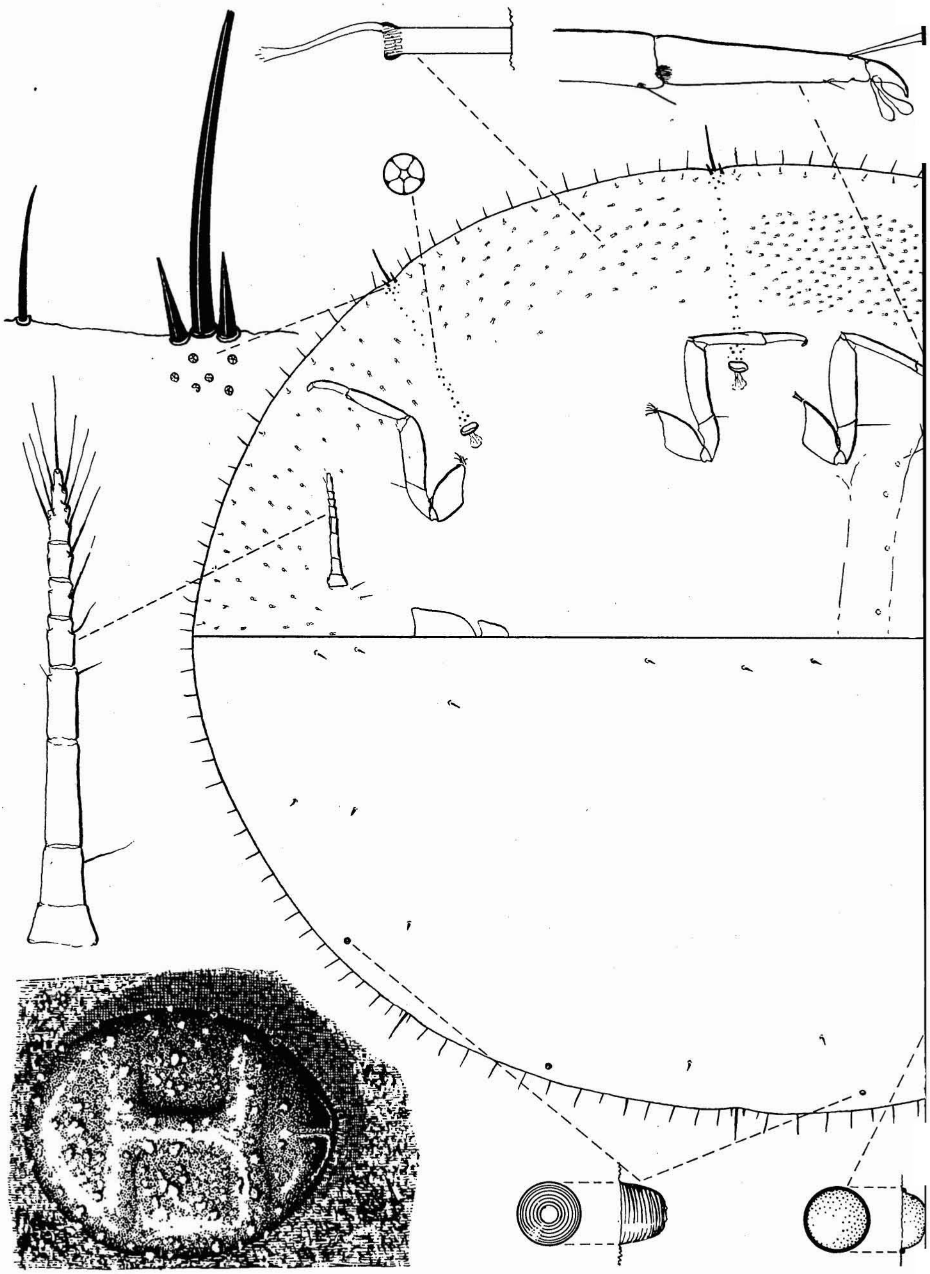
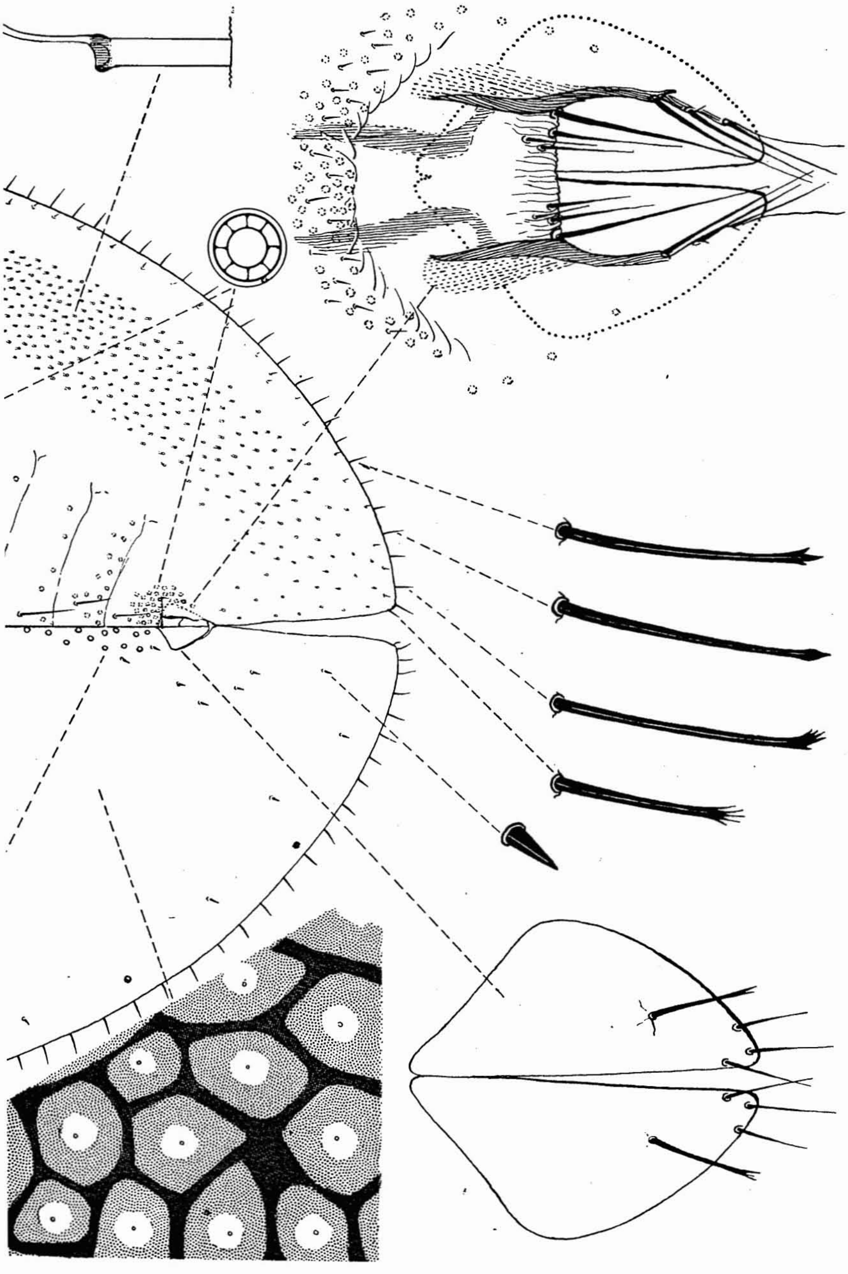


Figure 168—*Saissetia oleae* (Bernard), the black scale. (Drawn by Ferris.)



Genus **PULVINARIA** Targioni-Tozzetti, 1867

Among our species of the family Coccidae, the development of a cottony eggsac by the members of this genus makes them distinctive. The female scales are naked until egg-laying, at which time the eggsac is produced from broad, ventral, submarginal bands of tubular ducts. As the sac develops, the scale of some forms may become tilted strongly upward so that it appears to be nearly standing on its head (as in *Icerya*).

At full maturity the members of this genus may be recognized and separated from the members of all but a few small and obscure genera by the formation of a distinct ovisac which originates from the ventral side of the body. Immature specimens in last instar, but previous to formation of ovisac, may be placed generically—on basis of present understanding—by the following characters: Antennae well developed, slender, normally seven- or eight-segmented. Legs normally developed, having a movable tibio-tarsal articulation, tibia usually being wider at apex than tarsus is at base, tarsus with a distinct, sclerotic articulatory process. Stigmatic depressions normally with three stout setae, of which two are short and stout and third is three or four times as long as others, these setae always simple and definitely differentiated from remainder of marginal setae by both shape and size. Ventral side of body always with great numbers of small, tubular ducts from which ovisac arises, these present at least in a broad submarginal zone on abdomen and at times occurring even on ventral side of head and thorax. Multilocular pores usually present at least about base of anal cleft and at times even on thorax. In some species now referred to *Coccus* the tibio-tarsal articulation may approximate the condition which is typical of *Pulvinaria,* but in such species the tubular ducts, if present at all, are very few and never form a submarginal zone such as appears in *Pulvinaria.* (The foregoing paragraph is by Ferris.)

Key to the Species of Pulvinaria Reported from Hawaii

(Modified from keys prepared for this work by Ferris and Morrison.)

1. A relatively huge species, 6 to 10 mm. long, or longer; with about 20 small but well-developed submarginal tubercles; marginal setae slender, mostly entire, rarely slightly frayed at apices, about 36 microns long; dorsal derm beset with large numbers of small, thick-rimmed, somewhat 8-shaped pores, this derm at full maturity becoming sclerotized thoughout, each of the pores then occupying the center of a small, pale area.......................... **mammeae** Maskell.
   Much smaller species, not over 4 mm. in length; submarginal tubercles, if present, few, probably not exceeding 11; marginal setae shorter and mostly stouter, but sometimes variable, probably not exceeding 30–32 microns in length; derm at full maturity remaining membranous.................. 2
2. With a few submarginal tubercles (4–11); marginal setae stout, usually strongly expanded and strongly fimbriate or

fringed apically; spiracles each with an oval plate in addition to usual spiracular apodeme..............**psidii** Maskell.
Submarginal tubercles apparently absent; marginal setae more slender and quite variable in length and appearance, mostly entire, or nearly so, rarely a few rather strongly fimbriate apically; spiracles with usual apodeme only.... ....**urbicola** Cockerell.

Pulvinaria mammeae Maskell (figs. 169, 170).
Pulvinaria mammeae Maskell, 1895:59, pl. 5, figs. 8–11.

Oahu (type locality: Honolulu ?).

The large cottony scale.

Immigrant. Also known from America. It was first found in the Territory by Koebele in January, 1894.

Hostplants: avocado, coffee, ferns, *Ficus palawanensis, Ficus variegata,* fig, *Hibiscus, Mammea americana,* mango, orange, plum, pomegranate.

Parasites: *Microterys kotinskyi* (Fullaway), *Microterys flavus* (Howard) (Hymenoptera: Encyrtidae).

Predators: *Cryptolaemus montrouzieri* Mulsant, *Rodolia cardinalis* (Mulsant) (Coleoptera: Coccinellidae).

This species is one of our largest coccids, and if taken with its fully developed ovisac, it is our largest species. I have examined slide-mounted specimens 8 to 10 mm. in length, and the great mass of fluffy "cotton" of the eggsac reaches a length of at least 25 mm. in some specimens. These creatures hardly appear to be insects when one views them on their hostplants. Instead, they seem to be isolated clusters of cotton which have become stuck fast after blowing onto the host. I have seen only isolated specimens on twigs and branches but never clusters of individuals.

Ferris has supplied the following information:

Recognition characters: From very broadly oval. Derm of dorsum becoming quite sclerotic at full maturity. The dorsum beset with great numbers of small, thick-rimmed, 8-shaped pores arranged in such fashion as to surround small circular or polygonal, poreless areas, and at full maturity each of these pores occupies the center of a small, oval, clear areolation, so that at maturity the derm is very much areolated. Just anterior to anal plates is a median series of perhaps 50 circular or oval pores with granulated disc. Dorsum with very few, scattered, small, stout, pointed setae. Marginal tubercles present, very small, there being as many as perhaps 13–14 on each side of body. Marginal setae all slender, of various lengths, some being quite long, some with apex simple, others apically slightly branched or fimbriate. Anal plates together about as wide as long, each with anterior-lateral margin somewhat shorter than posterior-lateral margin, and with nothing distinctive about the setae. Venter of the abdomen with a large group of multilocular pores on each side of anal cleft and with clusters or rows of such pores on all segments. Great numbers of small, tubular ducts present, these forming a broad, submarginal zone that extends forward on each side almost to anterior

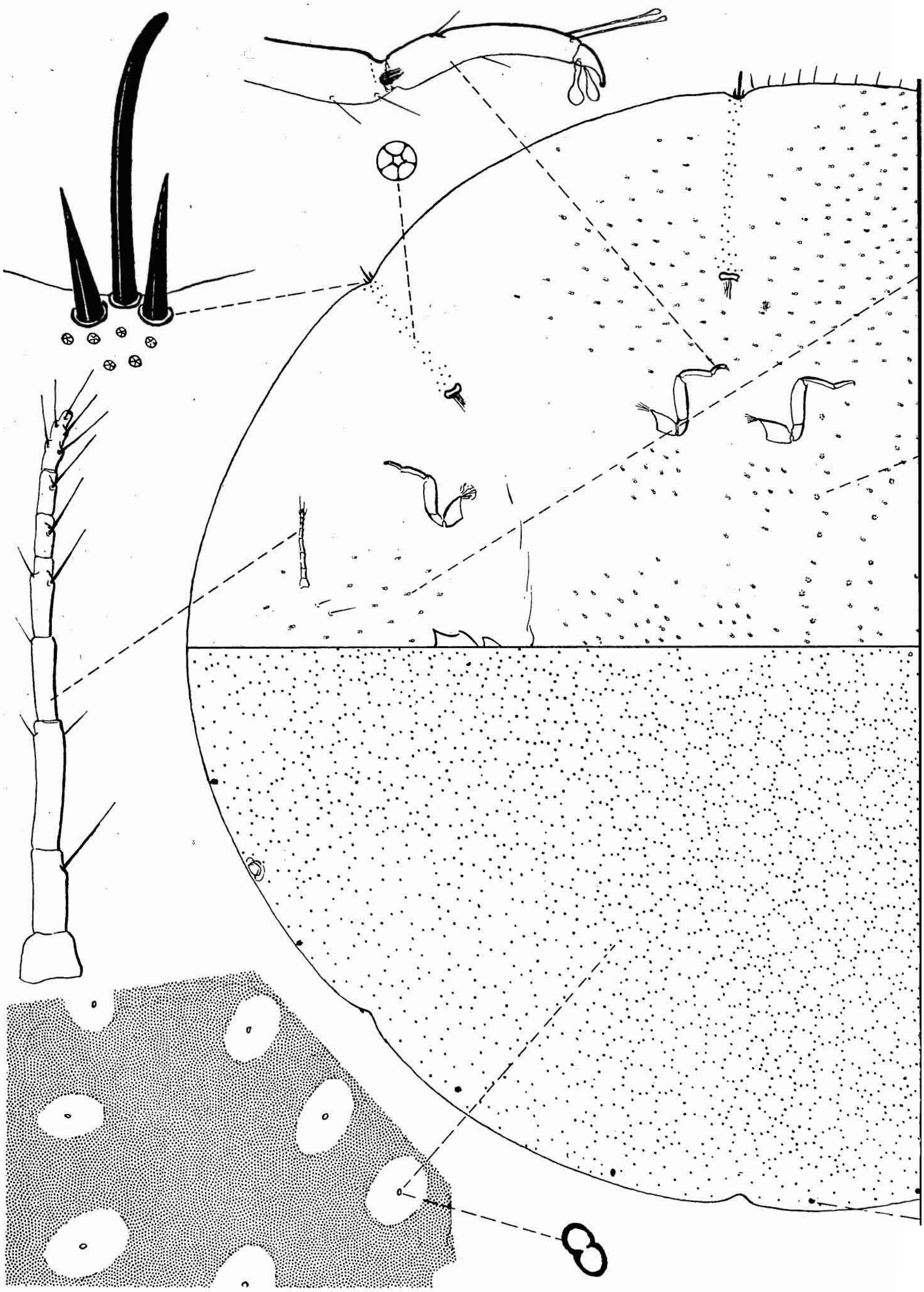
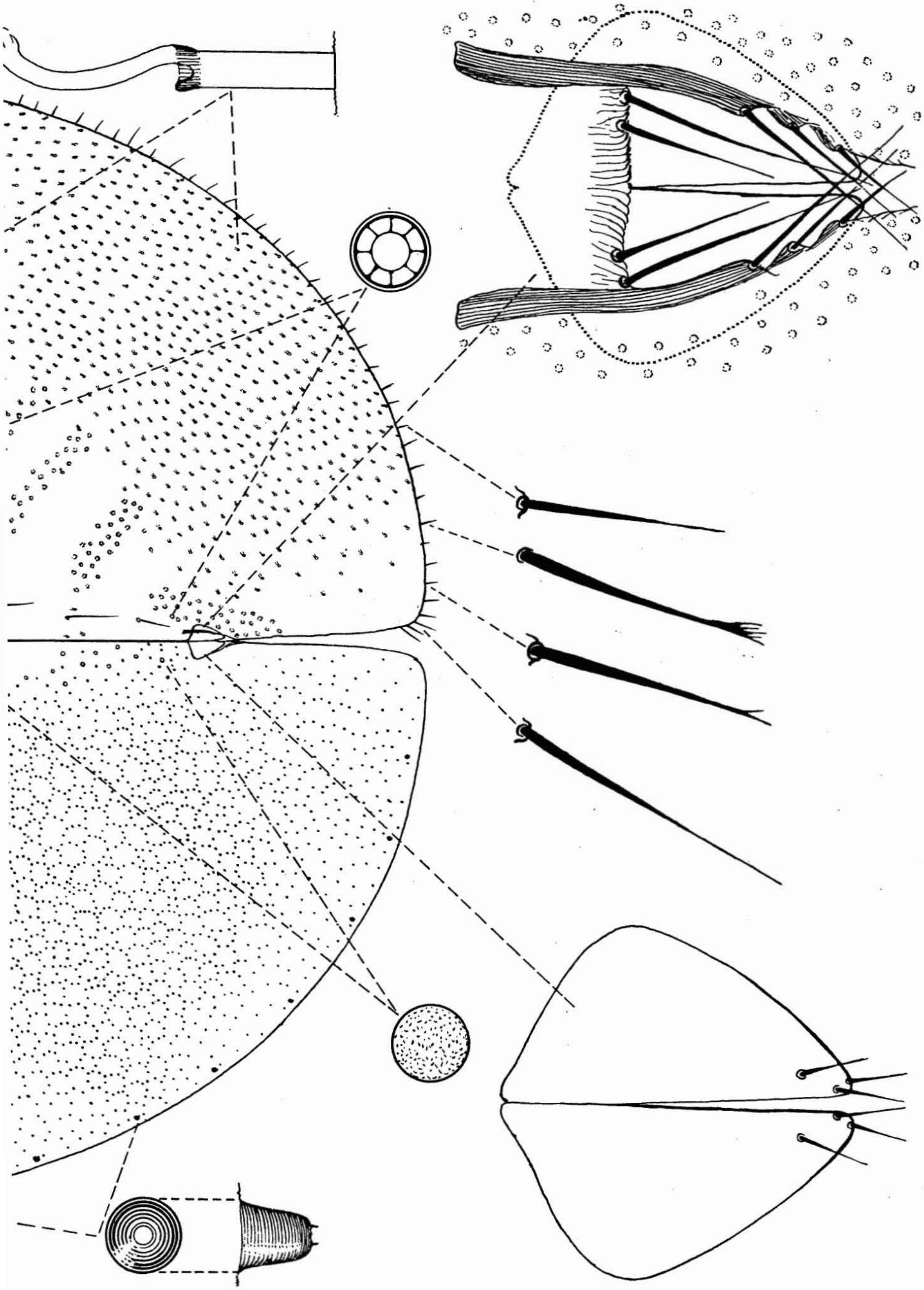


Figure 169—*Pulvinaria mammeae* Maskell, the large cottony scale. (Drawn by Ferris from material from the type series and from *Hibiscus* from Hawaii.)



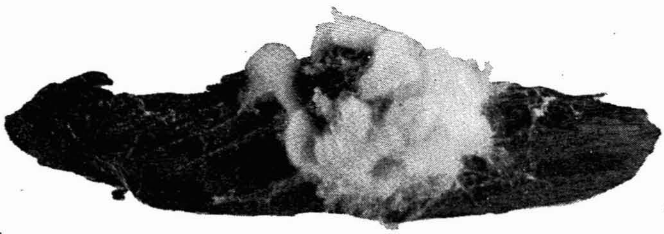


Figure 170—*Pulvinaria mammeae* Maskell, the large cottony scale, on mango twig (twice natural size).

thoracic spiracle and present also in smaller numbers across median region of abdomen, in median region of thorax and even on head in front of mouth parts. Antennae eight-segmented, rather noticeably slender. Legs normally developed, with movable tibio-tarsal articulation, tarsus with an articulatory sclerosis.

Notes: There are at hand three specimens of this species, two from the type material in the Koebele Collection and one from *Hibiscus*, Honolulu, 1907. The most distinctive structural feature of the species is the great number of small, 8-shaped pores on the dorsum.

Pulvinaria psidii Maskell (figs. 171, 172).

Pulvinaria psidii Maskell, 1892:223, pl. 13, figs. 10, 11.

Oahu, Molokai, Hawaii (type locality: Kona ?).

The green shield scale.

Immigrant. Now a widespread species, and thought to be of Oriental origin, although first described from Hawaii.

Hostplants: *Anthurium*, avocado, *Bouvardia*, *Citrus*, coffee, *Eugenia jambos* (rose apple), ferns, *Gardenia* (may be a serious pest on this host), guava, *Morinda citrifolia*, orange, *Phlox*, pomegranate, *Schinus* (pepper tree), *Straussia*.

Parasites: *Microterys kotinskyi* (Fullaway), *Microterys flavus* (Howard) (Hymenoptera: Encyrtidae).

Predator: *Cryptolaemus montrouzieri* Mulsant (Coleoptera: Coccinellidae).

Koebele (1898:107–108) stated that the species

had spread considerably over the Islands, and caused some anxiety, especially in the coffee districts. I myself must confess that nowhere have I ever seen a landscape so completely blackened by the fungoid growth, caused by the honey exudation of the Pulvinaria scale in which this grows, as that of North Kona on my visit in February, 1894. On my recent trip to the same place, all this had changed, and the district, to me, had the appearance of another country, all owing to the presence of the Cryptolaemus beetle that devours the eggs of the scale. Since then various other species of lady birds were sent there, and still more will be sent, all of such that will prey both upon the eggs and mature insects.

Perkins (1897:499) said:

When I visited the Kona district of Hawaii in 1892, many of the trees were literally festooned with the masses of this pest, and appeared on the point of being totally destroyed.

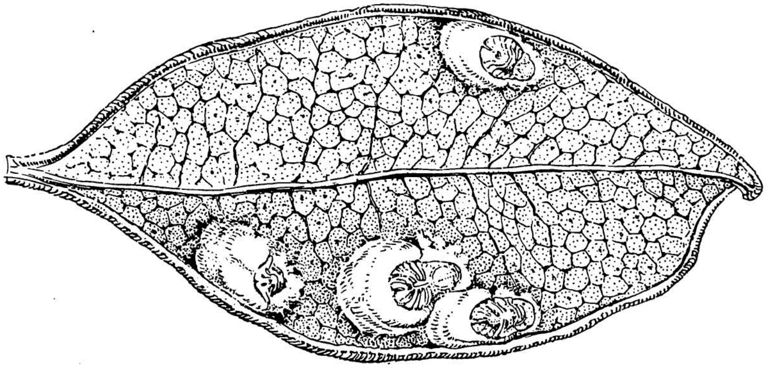


Figure 171—*Pulvinaria psidii* Maskell. (Abernathy drawing.)

In 1894 the ladybirds were sent there, and very soon had entirely changed the condition of things, and the affected trees speedily recovered. To show the vast increase of this species of ladybird [*Cryptolaemus montrouzieri*], I may state that in June of the present year many large trees in the city of Honolulu had several square feet of their bark entirely hidden by the larvae, which formed great white masses, presenting such an extraordinary appearance that I much regret not having obtained photographs of some of the trees.

This species is sometimes confused with *Coccus viridis,* and some of the records of that species belong to this one.

The following notes are by Ferris:

Habit: On leaves and tender young stems of host.

Recognition characters: Length on slide about 3.5 mm. Form oval. Derm of dorsum remaining membranous at maturity, structureless except for perhaps 30 small round disc pores with granular center which lie along median line just anterior to anal plates and for excessively minute, scattered pores and a few very small, pointed setae. Anal plates with posterior-lateral margin of each plate slightly longer than anterior-lateral margin. Marginal setae all, or almost all, with apex flattened and expanded and variously fimbriate. Submarginal tubercles present, there being five or six on each side. Venter of abdomen with numerous multilocular pores about base of anal cleft and such pores present in small numbers across median region of most of abdominal segments. A few such pores may be present on thorax near spiracles. Tubular ducts abundant, occurring in a broad submarginal zone on abdomen and in small numbers across median region of abdomen; present also in groups on thorax, both in median and lateral regions and also on head, even anterior to antennae. Supporting bars of anal plates connected anterior to anal fold. Antennae normally eight-segmented, rather slender. Legs of normal development, with movable tibio-tarsal articulation and a distinct articulatory sclerotization on tarsus. Spiracles each with a distinct, oval spiracular plate in addition to usual spiracular apodeme.

Notes: The peculiar spiracular plates are perhaps the most distinctive single feature of this species.

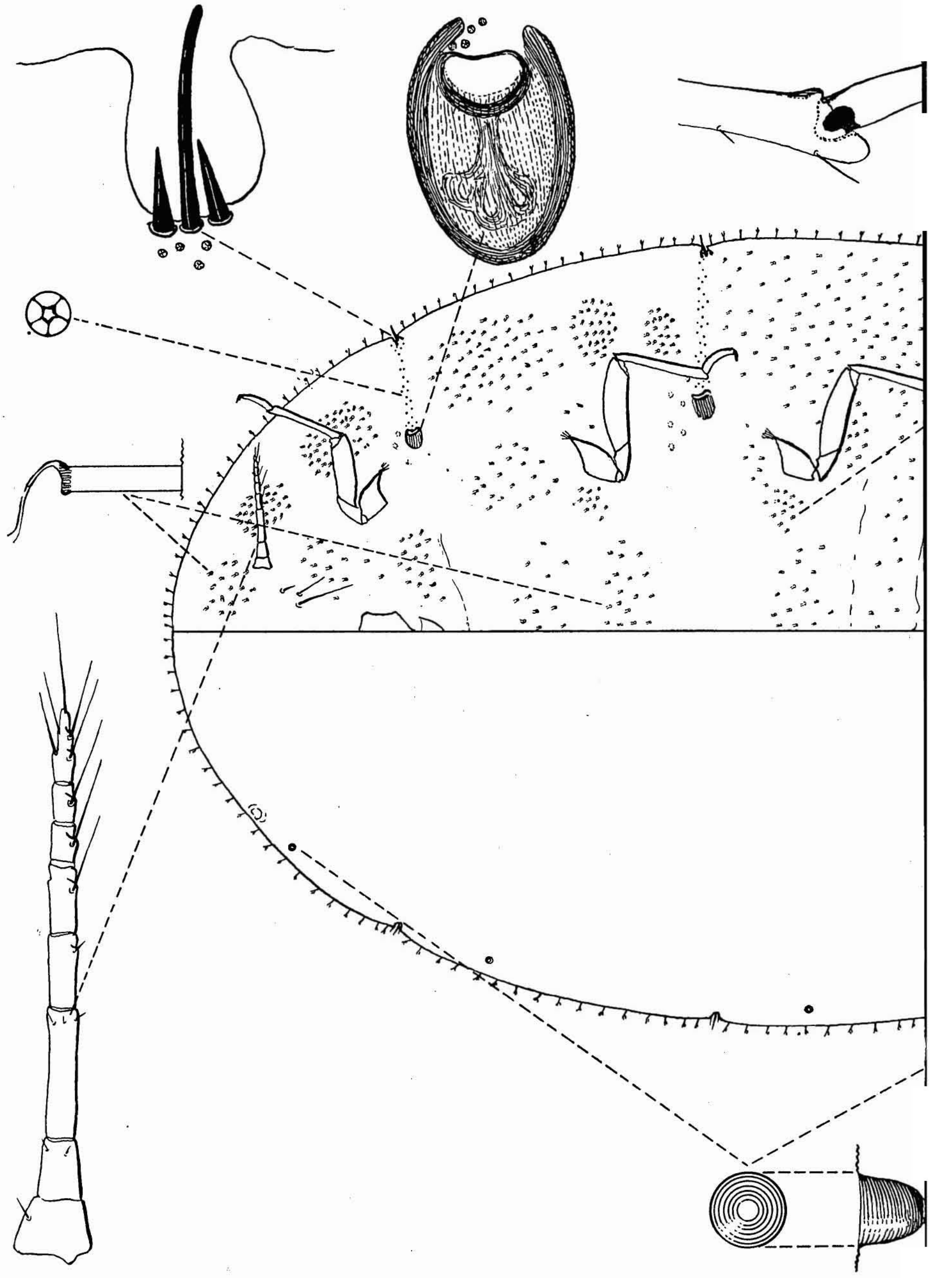
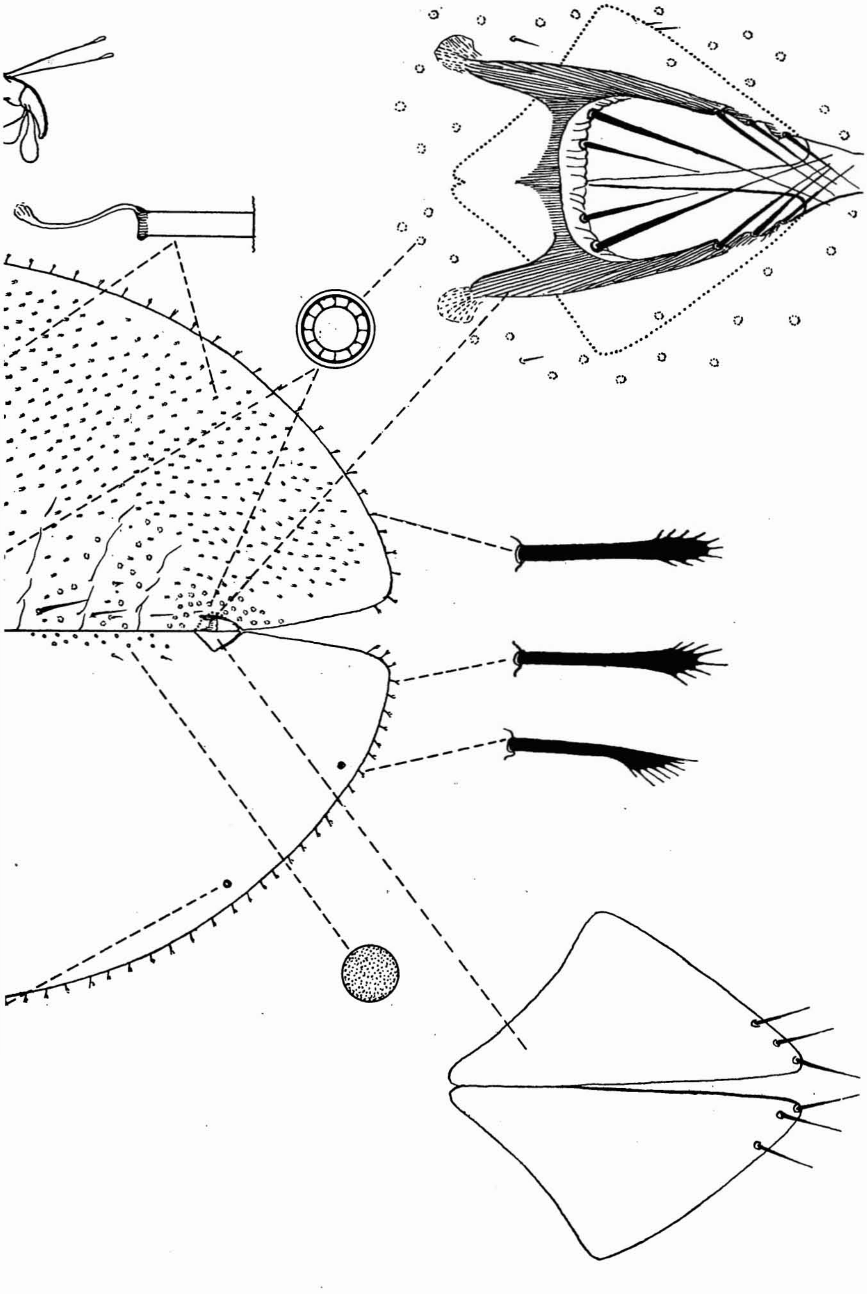


Figure 172—*Pulvinaria psidii* Maskell, the green shield scale. (Drawn by Ferris.)



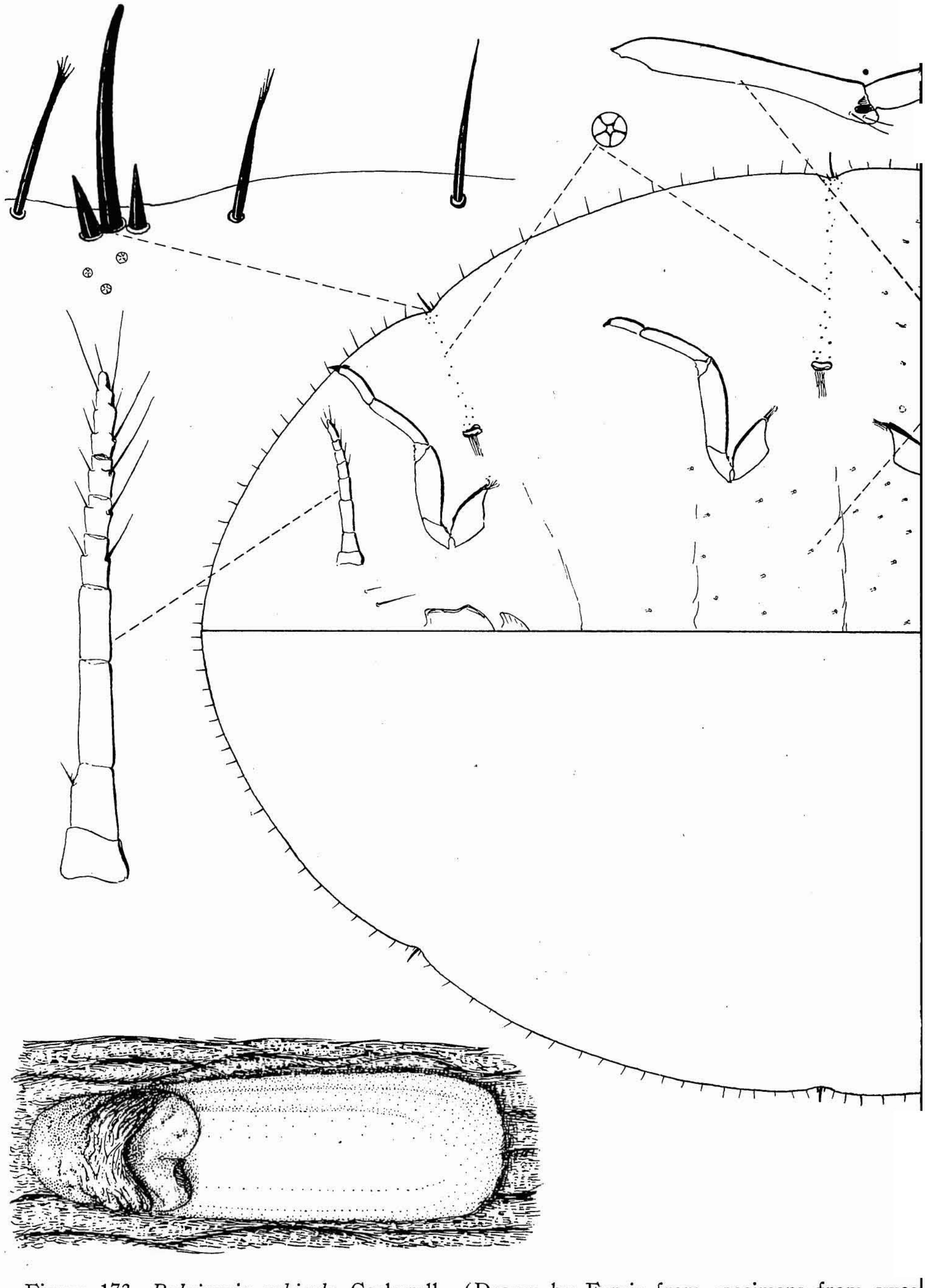
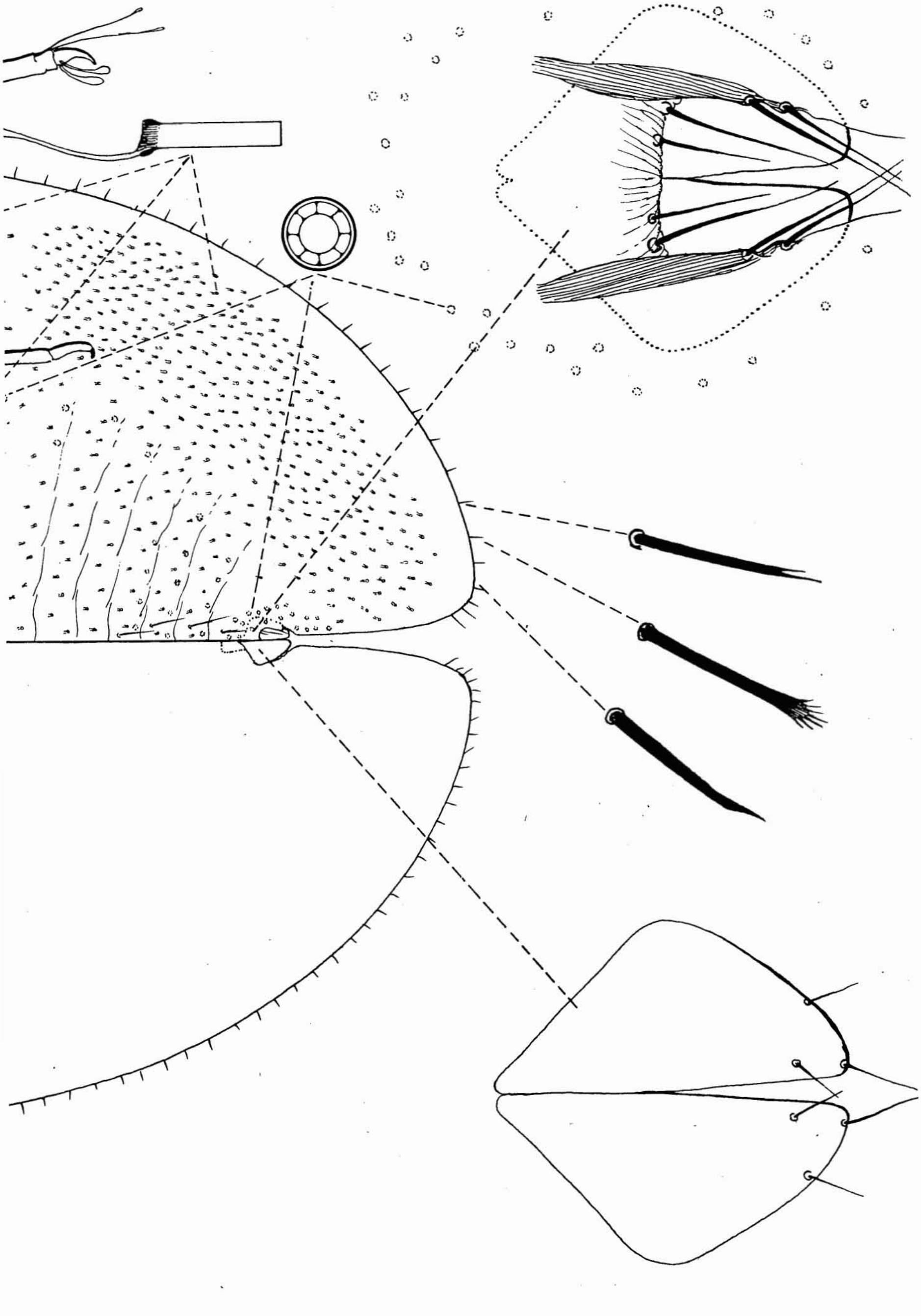


Figure 173—*Pulvinaria urbicola* Cockerell. (Drawn by Ferris from specimens from sweet potato, Honolulu.)



The accompanying illustrations are based upon specimens from "rose apple," Honolulu, in the Koebele Collection. The type material of the species should be represented in this collection but I have been unable to find it.

Pulvinaria urbicola Cockerell (fig. 173).
Pulvinaria urbicola Cockerell, 1893:160.

Oahu.

Immigrant. An American species originally described from Jamaica. First listed from Hawaii by Kotinsky in 1909 (*Proc. Hawaiian Ent. Soc.* 2(2):72) as *Takahashia japonica* Cockerell (?).

Hostplants: *Capsicum,* Kuhio vine (*Ipomoea horsfalliae*), sweet potato.

Parasite: *Aneristus ceroplastae* Howard (Hymenoptera: Aphelinidae).

Predator: *Cryptolaemus montrouzieri* Mulsant (Coccinellidae).

Ferris has supplied the following notes:

Habit: In material at hand the insects occur on crown of host. At full maturity body of female becomes wrinkled and distorted; ovisac slender and very slightly fluted.

Recognition characters: Length of adult female on slide about 2.5 mm., it thus being a small species. Derm remaining membranous throughout, with no trace of sclerotization in any specimens examined. Dorsum entirely without structures other than a few, extremely minute, pointed setae, there being no dorsal pores of any kind and no submarginal tubercles. Marginal setae moderately large, straight or but slightly curved, quite stout and with apex either simple or variously divided or fimbriate. Anal plates almost quadrate, presenting no distinctive characters. Ventral side of abdomen with a broad submarginal band of small, tubular ducts and a few such ducts in median region. A few such ducts present also on median region of thorax between middle and posterior coxae. Multilocular disc pores present in a group about vulva and around base of anal cleft, with a few such pores present on other abdominal segments forward to thorax or even an occasional one on thorax itself. Antennae apparently normally eight-segmented. Legs with a distinct, movable tibio-tarsal articulation; tarsus with an articulatory sclerotization.

Notes: I do not know by whom the identification of this species with *Pulvinaria urbicola* Cockerell was made and am unable to vouch for the authenticity of the identification. I rather strongly suspect that the species recorded by Kotinsky as *Takahashia japonica* Cockerell, and which has been considered as identical with *urbicola,* may actually not have been this.

[In connection with the last remark by Ferris, the following is worthy of quotation from Kotinsky, 1910:127–128: "This is the species recorded as *Takahashia japonica* (Proc. Haw. Ent. Soc. II, No. 2, Sept., 1909). I am indebted to Prof. Cockerell for calling my attention to the erroneous identification. I have also seen since specimens of *Takahashia japonica,* sustaining Prof. Cockerell's correction. The antennal formula of our material, however, does not at all agree with that given by the author, so that our species remains indefinitely identified."]

Genus **CEROPLASTES** Gray, 1828

The adult females of this genus are easily recognized because they are completely covered with a thick, rather amorphous mass of wax. They are frequently not considered insects by laymen.

In addition to *rubens,* listed below, *ceriferus* (Anderson, 1791) and *floridensis* Comstock, 1881, have been recorded from Hawaii, but these records are now believed to have been erroneous.

The following summary is by Ferris:

Coccoidea belonging to the family Coccidae, that is, with retractile anal opening covered by an operculum formed of two more or less triangular plates. Distinguished from other genera of the family by having marginal setae in stigmatic clefts numerous, short, stout and conical or hemispherical; by having anal operculum surrounded by a sclerotized area which tends to be more or less elevated and produced, the plates thus borne at apex of a more or less conical projection; body covered with an adherent mass of wax.

Genotype: *Ceroplastes janeirensis* Gray.

Notes: This is a very large genus containing somewhere between 75 and 100 named species. Species are known from every biogeographical region, but they are almost exclusively tropical, subtropical or warm-temperate forms. No critical study of more than three or four species has ever been made, and, consequently, it is not known whether or not the genus is actually a homogeneous group. The insects are difficult to study in microscopic preparations, because the body of many of the species becomes sclerotized and pigmented at maturity. This, combined with their very convex form, makes it necessary to obtain specimens taken early in the last instar if study of the microscopic structures is to be undertaken. In the absence of such preparations, identifications will depend chiefly upon the appearance of the test.

One species is known from Hawaii, this being a widely distributed form in the Oriental, Australian and Polynesian areas.

Ceroplastes rubens Maskell (figs. 174, 175).
Ceroplastes rubens Maskell, 1892:214, pl. 12, figs. 6–10.

The red wax scale.

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. A widespread species thought to have been introduced from China. First found in the Territory by Koebele in 1894.

Hostplants: *Aglaonema modesta, Antidesma, Asplenium, Citrus, Elaeocarpus bifidus, Elaphoglossum reticulatum, Eugenia,* ferns, mango, *Metrosideros, Myrsine, Pelea, Pittosporum, Stanhopea, Straussia.*

Parasites: *Microterys kotinskyi* (Fullaway), *Microterys flavus* (Howard) (Hymenoptera: Encyrtidae); *Tomocera californica* Howard, *Tomocera ceroplastis* Perkins (Hymenoptera: Miscogasteridae); *Aneristus ceroplastae* Howard (Hymenoptera: Aphelinidae).

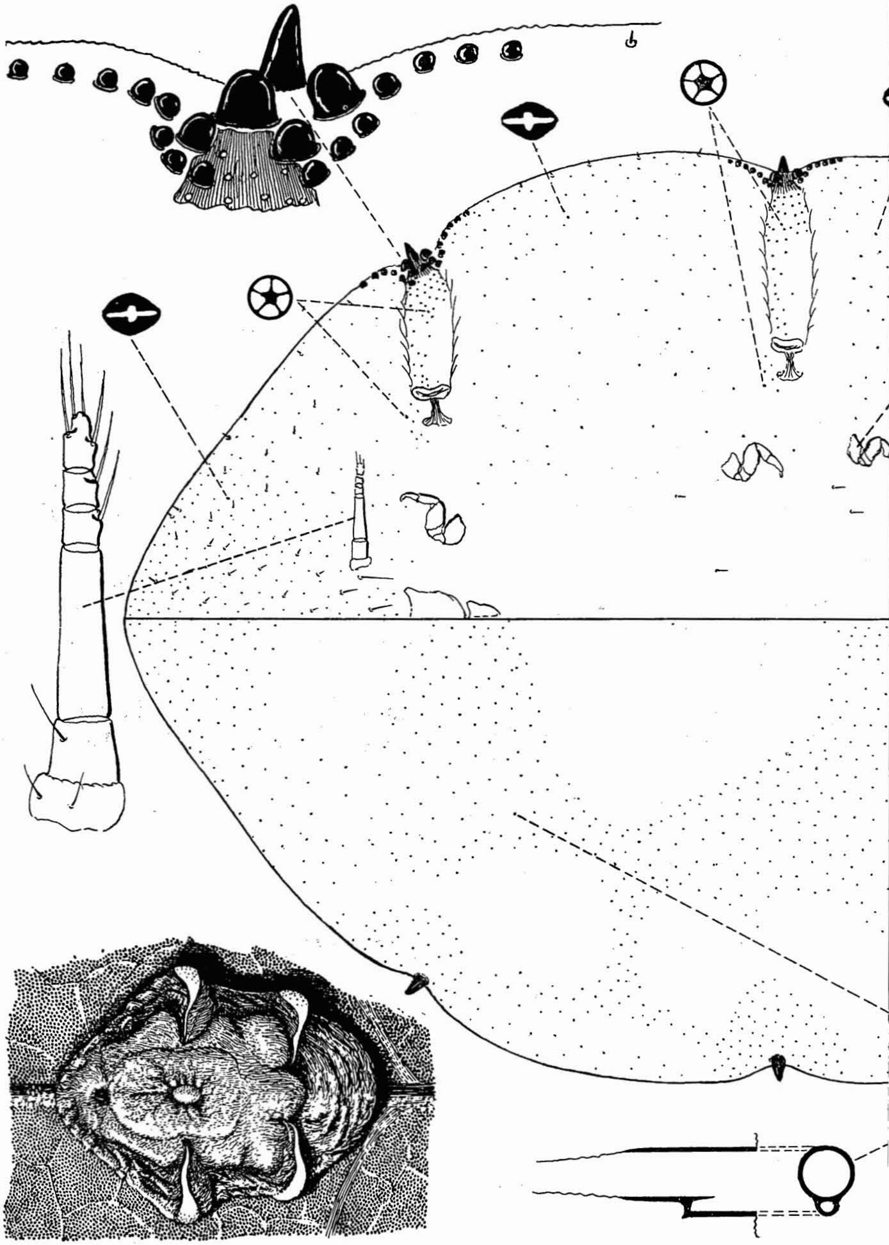


Figure 174—*Ceroplastes rubens* Maskell, the red wax scale. (Drawn by Ferris.

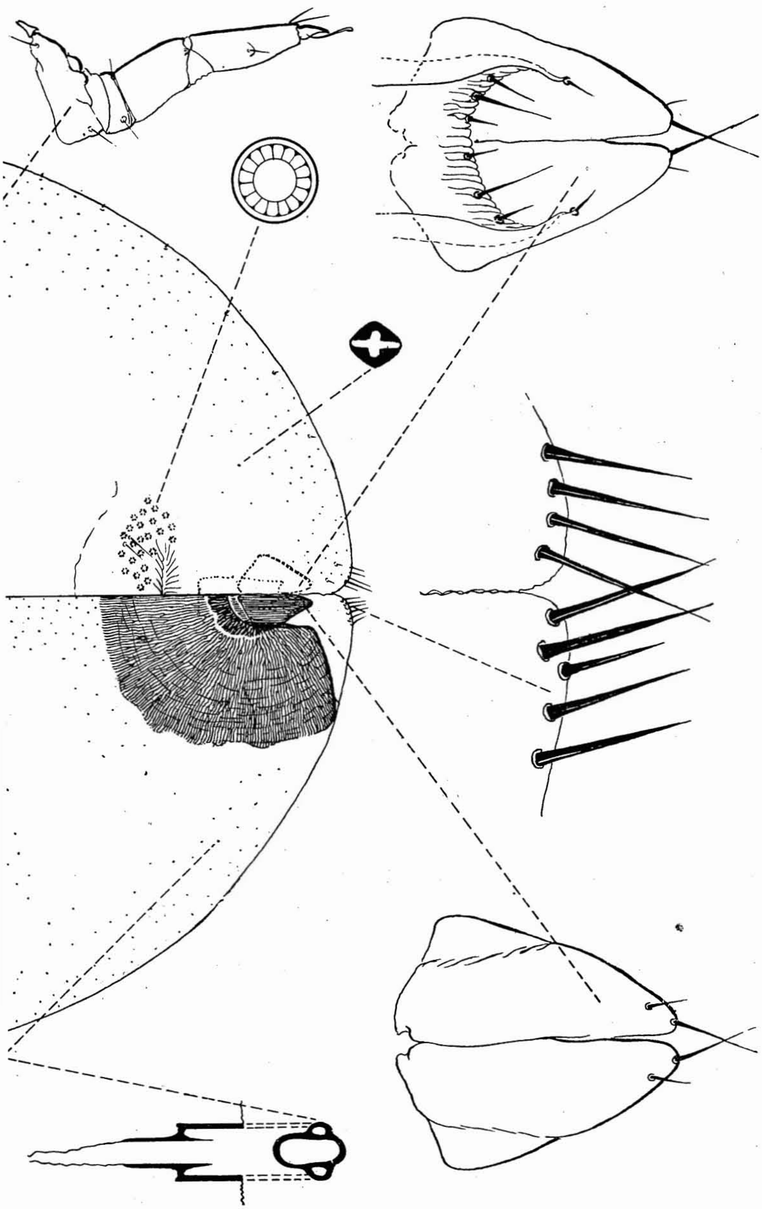


Figure 175—*Ceroplastes rubens* Maskell, the red wax scale, on a *Metrosideros* leaf.

It is a common, widespread species which has extended its range far up into the native forests where it feeds upon a number of native plants.

The following summation is by Ferris:

Material has been examined from the following hosts and localities: from mango and other hosts in Samoa; from *Citrus* sp. in Formosa; from undetermined hosts at Nagasaki, Japan, and from *Citrus* in Japan; from undetermined host at Honolulu, Hawaii.

Habit: Occurring either on leaves or twigs. The waxy tests are described as having a pinkish color in fresh specimens, but it has been noted by Morrison that this color disappears in old specimens, which become gray or slightly brown, the wax being somewhat translucent. The form seems to vary somewhat, at times being merely a rather shapeless lump, but always the test is marked by four conspicuous, transverse, white bands of powdery wax. This wax originates in the stigmatic furrows and undoubtedly serves to keep the spiracles from becoming closed. The test may be as much as 2.5 mm. long.

Morphological characteristics: At full maturity derm remains more or less membranous, becoming strongly sclerotized only in head region and in a somewhat circular area about anal operculum, latter area forming a slightly cone-shaped elevation. This anal sclerotization does not close posteriorly behind anus. Antennae well developed, normally six-segmented, with third segment forming almost half of total length. Legs much reduced, stout and misshapen.

Margin of body with only a few extremely minute setae, except for a tuft of slender setae at apex of each anal lobe and stout setae of stigmatic clefts. Associated with each cleft there is a single, very stout, cone-shaped seta; ventrad

of this are usually two quite large and somewhat dome-shaped setae and ventrad of these a row of as many as six smaller, sometimes almost spherical, setae extends along each side of the cleft. Anal tubercle quite short, increasing in size during last instar until full maturity is reached and therefore being somewhat variable both in form and extent. Anal plates slightly elongate, bearing only two or three slender setae at apex of each. At least five types of dermal pores are present on body. Of these, those of one type are so few and so delicate that they may be omitted from consideration. The dorsum of the body is beset with great numbers of very small pores which have a bilocular or trilocular appearance and which open into a peculiar type of duct that is shown in accompanying illustration. These pores are quite variable both in form and size. In a small, well-stained specimen it can be seen that they are distributed in a pattern which seems to leave some areas bare. On the ventral side of the body, especially in the marginal regions, are numbers of a still smaller pore which is somewhat lozenge-shaped with a central, cruciform orifice. About the vulva is a cluster of multilocular disc pores. In the stigmatic furrows and about the spiracles are numbers of a very small stellate pore.

Notes: The accompanying drawings are based upon specimens from mango in Samoa. All the other specimens from Japan, Formosa and Hawaii which have been examined in connection with this study agree very well with these and all agree with the concept of the species as held by Green and with the original description as far as it goes. The identification seems to be reasonably certain. The pink or brown color of the test, with the conspicuous, transverse white bands, seems to distinguish the species in unmounted specimens, while the form of the antennae, the short legs, the arrangement of the stigmatic setae, the absence of a row of marginal setae, and the rather small, sclerotized anal area seem to mark it in preparations.

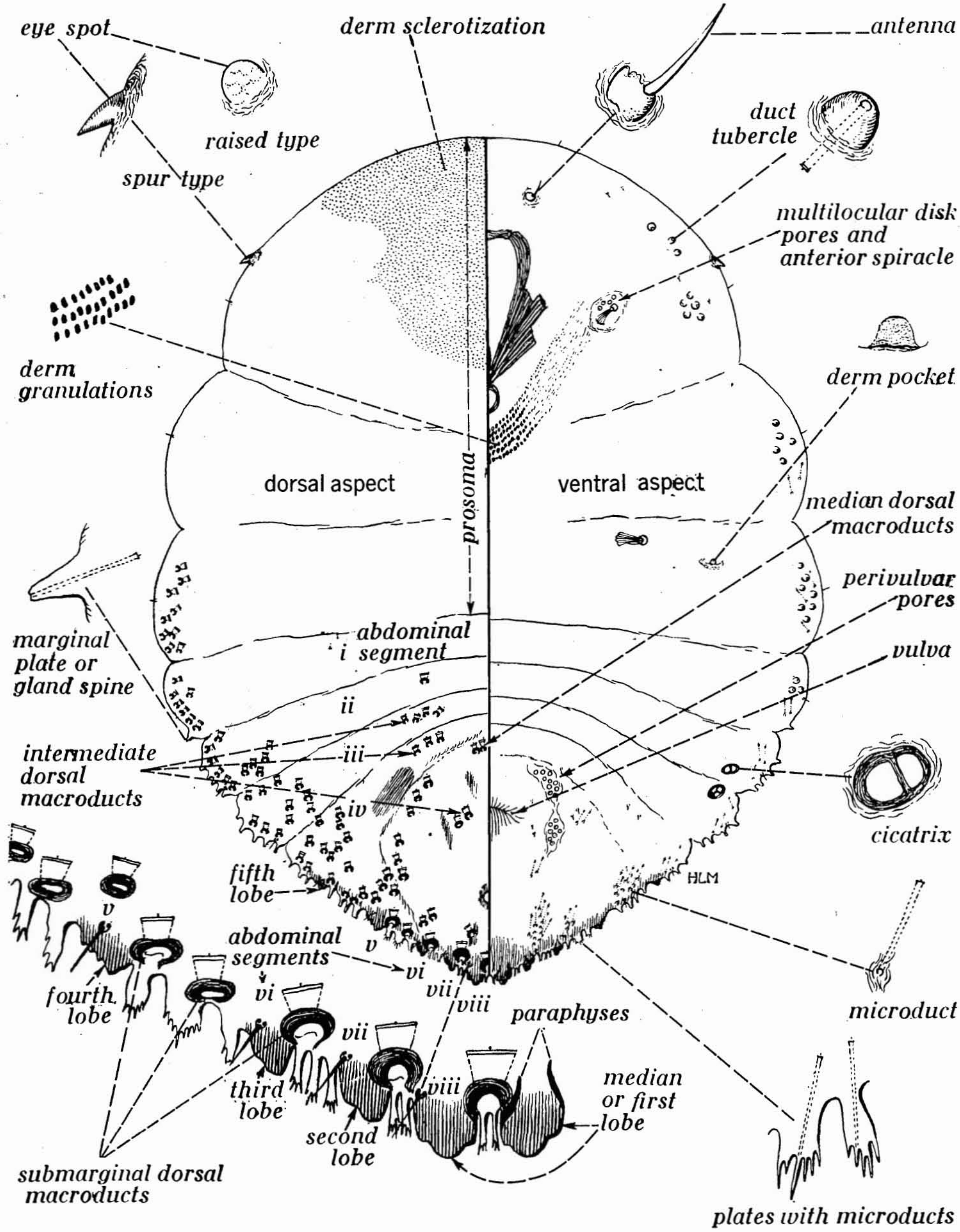


Figure 176—Details of a diaspine scale (*Parlatoria*, diagrammatic). (Drawing kindly furnished by H. L. McKenzie.)

Family **DIASPIDIDAE** Maskell, 1878

The Armored Scales

This is the largest and most complex group of the Coccoidea. Fortunately, there exists a unique and remarkable monograph upon which the writer may lean for aid and guidance. It is the monumental *Atlas of the Scale Insects of North America* by Professor Ferris, the completed parts of which include the diaspid scales. Nearly all of the Diaspididae recorded from Hawaii are treated in the Ferris volumes. It would be presumptuous to attempt to add much to Ferris' work. Much of the taxonomic material in the following text is abstracted or recast from Ferris, and grateful acknowledgment hereby is given. Under each species I have included references to Ferris' work, if the species has been discussed by him. Thus, for detailed diagnoses and notes, the reader may refer to Ferris; surely for morphological outlines, reference to the extensive, lucid, descriptive material of Ferris must be made.

At the completion of his studies, Ferris gave the following diagnosis of the Diaspididae:

> With the antennae in all stages except the first composed of an unsegmented tubercle. With the legs in all stages after the first entirely lacking or at the most represented merely by unsegmented tubercles. With the terminal segments of the abdomen more or less fused into a compound structure, the pygidium, which is more or less set off by an intersegmental constriction, or by some differentiation of the segmental lines, or by dorsal sclerotization, from the preceding abdominal segments. Commonly this pygidium is in some degree dorsally sclerotized and surrounds the anal opening, while ventrally it is but partially sclerotized and bears the vulva. With tubular ducts almost always present, although at times few and very minute, these in part, at least, truncate at their inner extremity and with this extremity always symmetrical, there being a median, filamentous prolongation. Disc pores of a more or less quinquelocular type are normally present only in association with the spiracles and the vulva, if at all. With the pygidium commonly bearing marginal lobes and unsclerotized processes in the form of fringed plates or of gland spines. In habit, the adult female is normally covered by a scale which is formed from two exuviae and secretionary material, although at times the adult female is retained within the exuvia of the preceding stage. (1942:SIV–446:17–18.)

The eggs are deposited beneath the scales and reproduction may be sexual or parthenogenetic. As egg-laying progresses, the body of the female shrivels, and finally, when her egg supply is exhausted, her dead, shrunken body lies under some part of the covering scale and the remainder of the cavity is largely filled with eggs. Unlike many of the other coccids, the diaspids do not produce quantities of honeydew. Some of the most pernicious of coccids, such as the San Jose scale [*Quadraspidiotus perniciosus* (Comstock)], belong to this family. The injection of toxic materials at feeding may cause much damage, such as deformation, discoloration or death to plant parts. Some species develop in enormous numbers on their hosts.

Key to the Subfamilies of Diaspididae

(By Ferris.)

1. Adult female, even if enclosed within the second exuvia, with some evidence of the compound nature of the pygidium whether in the form of lobes, gland spines, plates, or marginal, segmentally arranged setae, or if these are much reduced or lacking the second stage always presents some one or more of these features; the pygidium always includes at least the fifth abdominal segment and sometimes the fourth; a scale composed of two exuviae combined with secretionary material is always formed, even though it may disappear in the course of development.................... **Diaspidinae.**
2. Adult female always enclosed within the sclerotized exuviae of the preceding stage; neither adult female nor second stage ever with segmentally arranged pygidial lobes, plates, gland spines or macroducts; never with furrows, ducts or marginal setae so arranged as to indicate segmental lines on the dorsum of the pygidium; pygidium apparently composed of no segments anterior at most to the sixth; never forming a scale which is composed of exuviae and secretionary material .... **Phoenicococcinae.**

Subfamily DIASPIDINAE

Most of the known species of the family belong to this subdivision whose characteristics are outlined in the foregoing key.

Key to the Tribes of Diaspidinae Represented in Hawaii

(Modified from Ferris.)

1. Adult female with no plates or segmentally arranged gland spines, with no paired lobes but commonly with a single median lobe; macroducts usually small and short, numerous, never in segmentally arranged rows, usually abundant on ventral side of pygidium as well as on dorsum........... .... **Odonaspidini.**

   Adult female normally with plates or gland spines, or second stage with them; macroducts commonly showing some evidence of arrangement in segmental rows or series; pygidial lobes usually present, median lobes rarely united into a single lobe; otherwise various........................ 2
2. Macroducts of "two-barred" type; second pygidial lobes usually showing some evidence of being bilobulate; gland spines normally present, although in some forms replaced by fringed plates, in latter case usually with gland tubercles; anterior spiracles commonly with associated disc pores; antennae of adult female commonly with two or more setae.............................. **Diaspidini.**

Macroducts of "one-barred" type; second pygidial lobes never bilobulate; fringed plates normally present; gland tubercles rarely present; anterior spiracles normally without associated disc pores; antennae of adult female rarely with more than one seta .... **Aspidiotini.**

Tribe ASPIDIOTINI

Key to the Genera Recorded from Hawaii

(Recast from Ferris.)

Adult Females

1. Dorsum of pygidium with a reticulate pattern formed by many small areas of weaker sclerotization .... **Duplaspidiotus** MacGillivray.
   Dorsum of pygidium without such a pattern 2

2(1). Pygidium without paraphyses and not as below (fourth pygidial lobe not at all developed) .... **Aspidiotus** Bouché.
   Pygidium with paraphyses arising from the bases of lobes or at the site of obsolete lobes 3

3(2). Paraphyses arising only from basal angles of lobes, never from within space between lobes, thus forming merely paired supports for lateral margins of intersegmental poriferous furrows 4
   With at least one paraphysis arising from about center of at least one interlobular space, ordinarily that between second and third lobes, frequently with paraphyses along the margin beyond third lobe 5

4(3). Only median lobes developed, elongate, mesally approximate; plates large and much fringed on lateral margins in our species, and diameter of anal opening much shorter than length of a median lobe .... **Morganella** Cockerell.
   Second and third lobes represented at least by a pointed process; anal opening large, its diameter about equal to length of a median lobe in our species .... **Hemiberlesia** Leonardi.

5(3). Prosoma much swollen and strongly sclerotized, varying in form from slightly reniform to very markedly so, lateral prosomatic lobes more or less enclosing pygidium .... **Aonidiella** Berlese and Leonardi.
   Without such a combination of characters 6

6(5). Plates present in mesal and first two spaces and all apically bifurcate, the forks slightly sclerotized and connected by a very delicate membrane......... **Furcaspis** Lindinger.
   Not so 7

7(6). Pygidium with a conspicuously developed series of paraphyses on margin of fifth and sixth segments .... **Lindingaspis** MacGillivray.
   Pygidium with no paraphyses anterior to third lobe..... .... **Chrysomphalus** Ashmead.

Genus **DUPLASPIDIOTUS** MacGillivray, 1921:394

Lattaspidiotus MacGillivray, 1921:394.
Ferris, 1938:SII–226.

Key to the Species Found in Hawaii

1. Perivulvar pores present..................**claviger** (Cockerell).
2. Perivulvar pores absent..............**tesseratus** (de Charmoy).

Duplaspidiotus claviger (Cockerell) (fig. 177).
Pseudaonidia clavigera Cockerell, 1901:226.
Duplaspidiotus claviger (Cockerell) MacGillivray, 1921:453.

Oahu.

Immigrant. A widespread species described from *Camellia* from South Africa. First recorded from the Hawaiian Islands by Kotinsky (1910:129).

Hostplants: Bombay mango, Chinese banyan, *Citrus*, fig, grape, *Hibiscus*, *Macadamia ternifolia*, *Santalum freycinetianum*.

Fullaway (*Proc. Hawaiian Ent. Soc.* 7(1):11, 1928) reported that "this scale mines under the bark and destroys the tissue" of grape on which it kills twigs. It is a thick, heavy, convex, gray species, circular or oval, with the exuvia subcentral; it is found on bark.

Duplaspidiotus tesseratus (de Charmoy) (fig. 178).
Aspidiotus (*Diaspidiotus*) *tesseratus* de Charmoy, Proc. Société Amicale Scientifique, p. 23, 1899 (I have not seen this reference).
Lattaspidiotus tesseratus (de Charmoy) MacGillivray, 1921:458.
Duplaspidiotus tesseratus (de Charmoy) Ferris, 1938:SII–227.

Oahu.

Immigrant. A widespread species described from Mauritius; apparently not listed in Hawaiian literature before, but intercepted in quarantine at San Francisco.

Hostplant: *Hibiscus*.

"Occurring on the bark. Scale of the female gray, circular or oval, high convex, very thick and heavy, exuvia subcentral." (Ferris.)

Genus **ASPIDIOTUS** Bouché, 1833

Ferris, 1938:SII–190.

As restricted by Ferris, this genus contains only two species in Hawaii. *Aspidiotus destructor* Signoret has been listed from Hawaii in error.

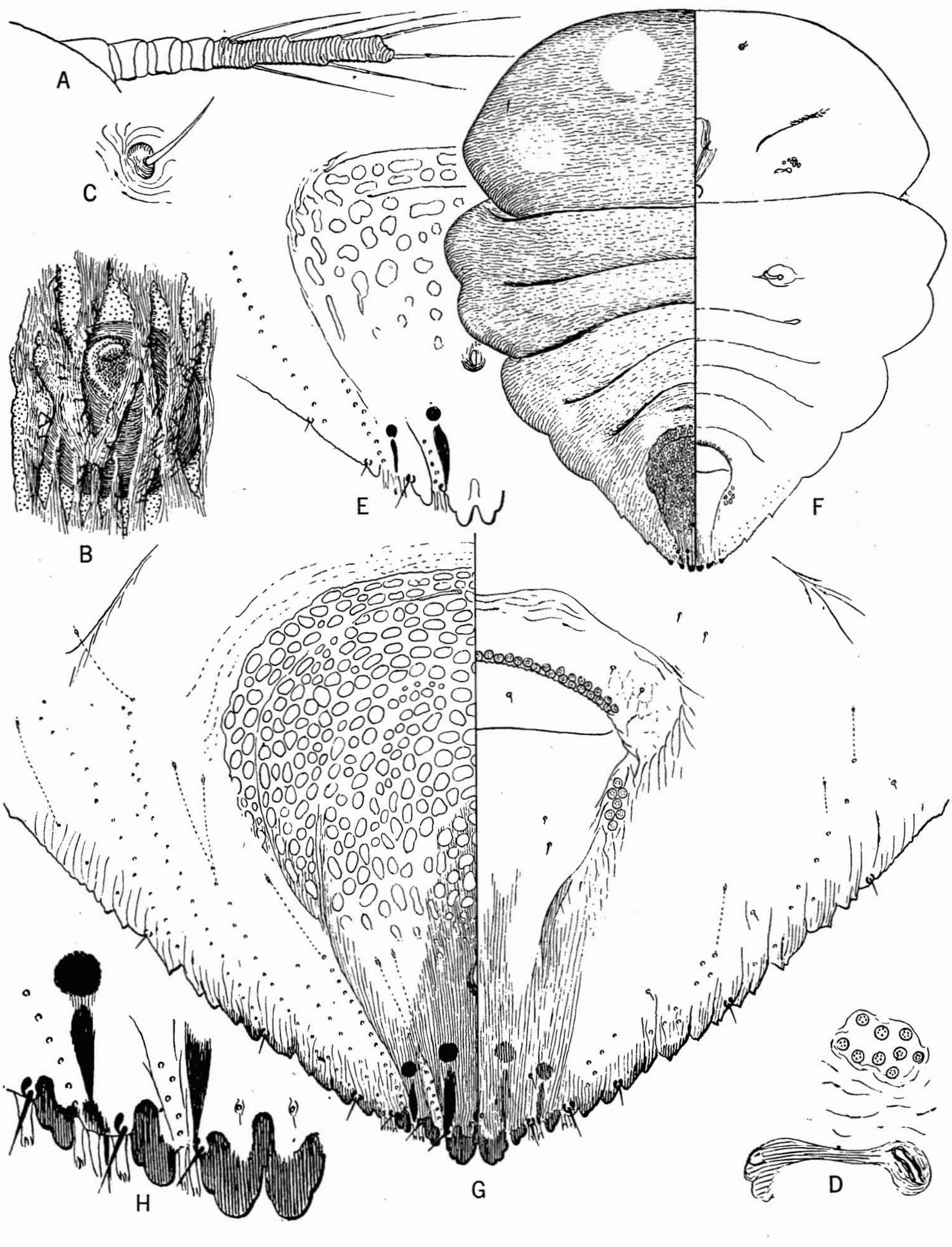


Figure 177—*Duplaspidiotus claviger* (Cockerell). (Drawn by Ferris.)

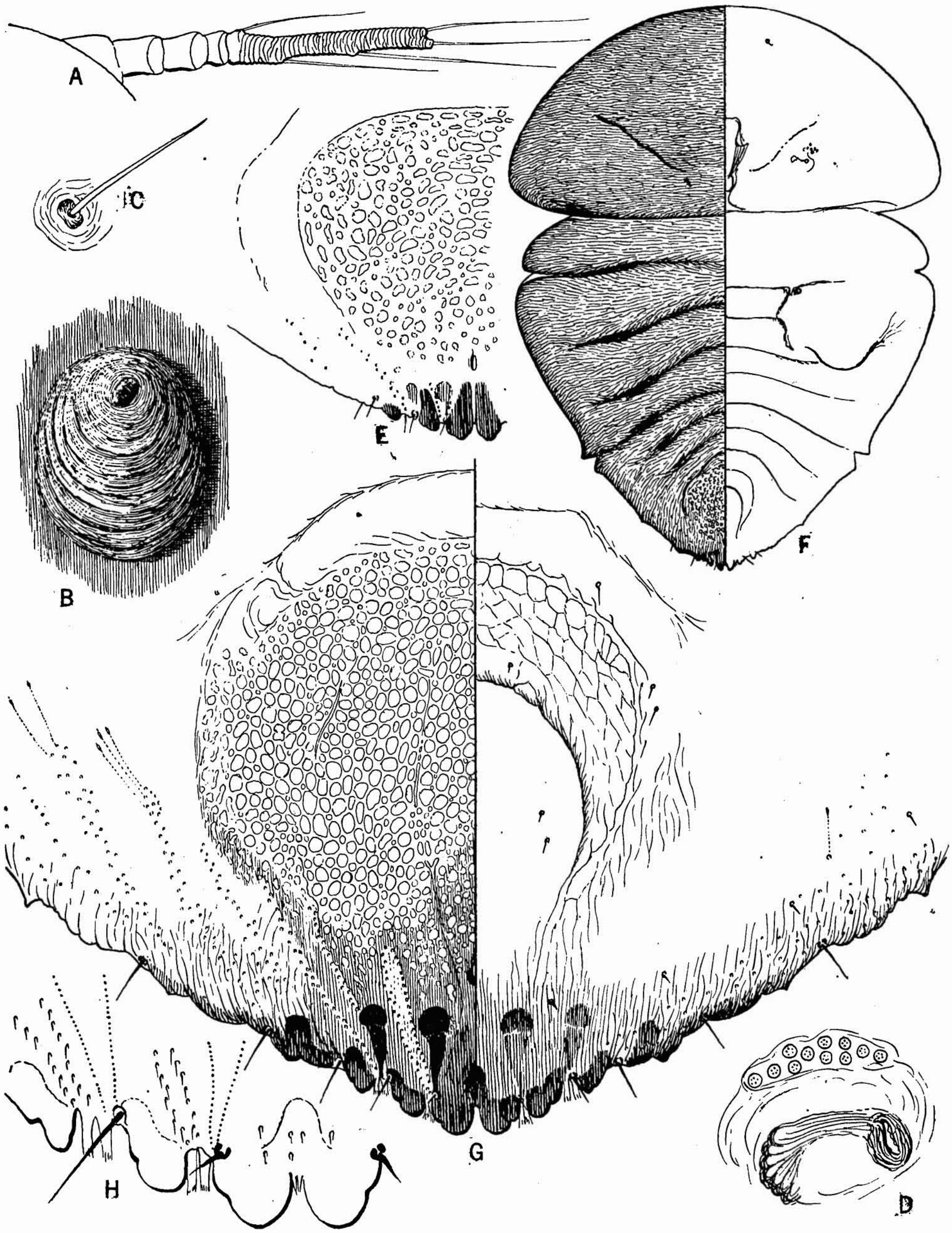


Figure 178—*Duplaspidiotus tesseratus* (de Charmoy). (After Ferris.) This and the following plates of the diaspine scales, unless otherwise indicated—and a number are original in this text—are reproduced from the original drawings previously published by Professor Ferris, mostly in his monumental *Atlas,* and which he has loaned for reproduction here. These plates have been reproduced through the kind permission of the copyright holders, the Stanford University Press. Acknowledgment is made for all of them here, and I have not repeated "After Ferris" on each of them. The new drawings made for this text are labeled "drawn for this text by Ferris." The standard system of labeling is as follows: **A,** antenna and cephalic margin of first stage; **B,** habit; **C,** antenna of adult female; **D,** anterior spiracle of adult female; **E,** pygidium of second stage female; **F,** general features of adult female; **G,** pygidium of adult female; **H,** dorsal aspect of detail of pygidial margin of adult female; **I,** ventral aspect of detail of pygidial margin of adult female; **J,** outline of exuvia of first stage. Not all these details will appear on every drawing.

Key to the Species of Aspidiotus Listed from Hawaii

(Recast from Ferris.)

1. Anal opening very small, close to basal scleroses of median lobes; ducts slender, but relatively short.. **spinosus** Comstock.
2. Anal opening larger and three or four times its own diameter removed from basal scleroses of median lobes; ducts conspicuously short and stout..................**hederae** (Vallot).

These species are small insects ranging from 0.75 mm. (*spinosus*) to 0.90 mm. (*hederae*) in length (slide-mounted adult females).

Aspidiotus hederae (Vallot) (fig. 179).

Chermes hederae Vallot, 1829:30.

Ferris, 1938:SII–192.

Oahu, Maui.

Immigrant. Cosmopolitan. First listed from Hawaii by Maskell in 1895 (p. 4, as *A. nerii* Bouché).

Hostplants: apple, *Diospyros ferrea,* oleander, palm, peach, pear, *Platydesma, Santalum haleakalae, Stigmatophyllon ciliatum.* According to Ferris it attacks almost all plants.

Scale flat, circular, white or yellowish; exuvia yellowish, subcentral; on bark or leaves; body of female pale yellow.

Aspidiotus spinosus Comstock (fig. 180).

Aspidiotus spinous Comstock, 1883:70, fig. 7 (note typographical error in spelling).

Aspidistus persearum Cockerell, 1898:240.

Ferris, 1938:SII–193.

The spined scale.

Oahu.

Immigrant. Nearly cosmopolitan. Described as *persearum* by Cockerell from Honolulu specimens taken by Craw at quarantine in San Francisco.

Hostplant: avocado ("The portion of the leaf attacked turns brown beneath, reddish above." Cockerell, 1898:240).

Scale flat, circular, dirty whitish or pale brownish, exuvia central; on bark or leaves.

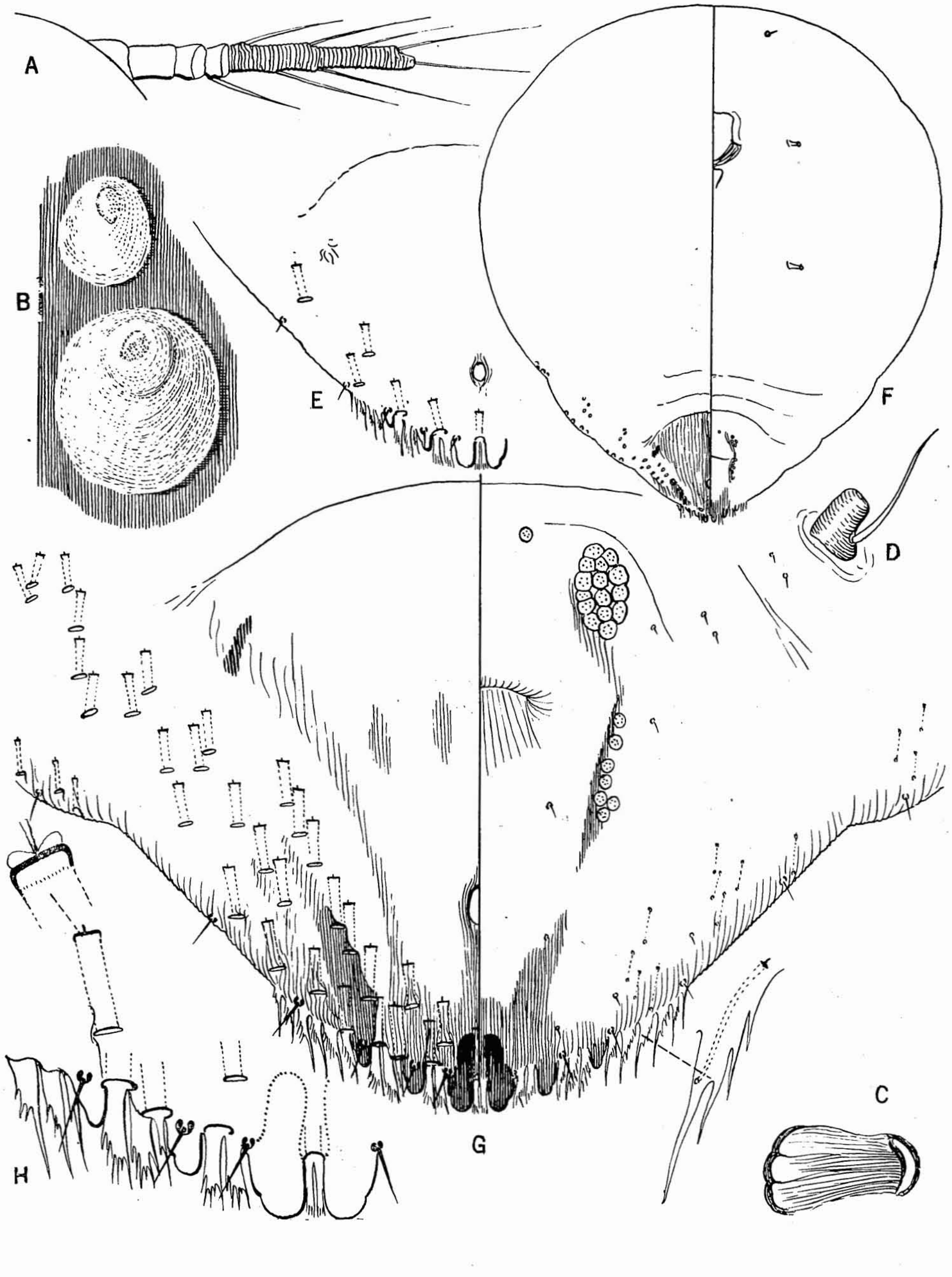


Figure 179—*Aspidiotus hederae* (Vallot).

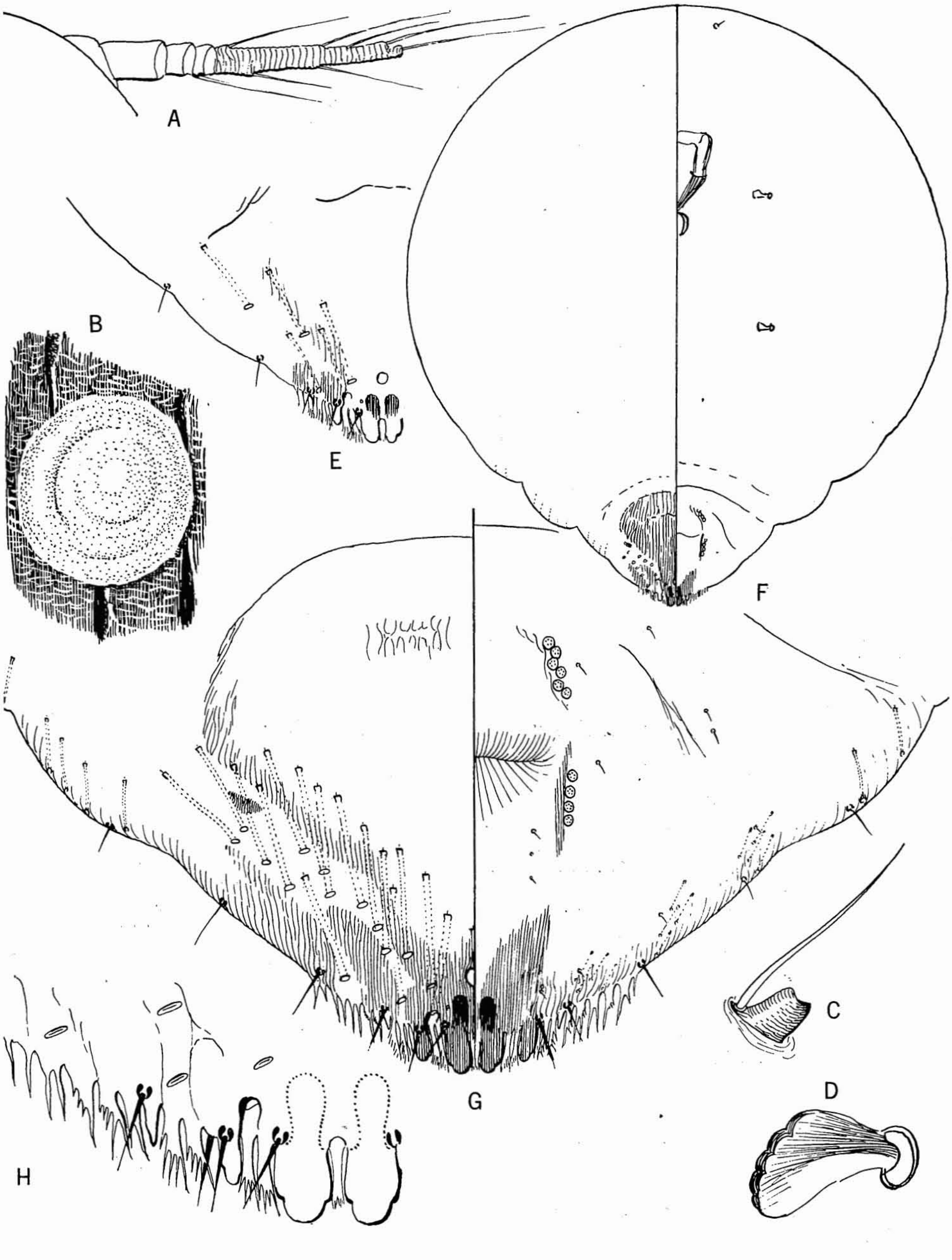


Figure 180—*Aspidiotus spinosus* Comstock, the spined scale.

Genus **MORGANELLA** Cockerell, 1897

Ferris, 1938:SII–247.

Morganella longispina (Morgan) (fig. 181).

Aspidiotus longispina Morgan, 1889:352, pl. 5, fig. 1.

Aspidiotus (*Morganella*) *maskelli* Cockerell, U. S. Dept. Agr. Tech. Series, Bull. 6:22, 1897 (I have not seen this reference).

Ferris, 1938:SII–249.

Oahu, Hawaii.

Immigrant. A widespread species, first listed from Hawaii by Maskell in 1895 (p. 4).

Hostplants: *Citrus,* fig, mango.

Parasites: *Archenomus perkinsi* (Fullaway), *Prospaltella koebelei* Howard (Hymenoptera: Aphelinidae).

Female scale convex, circular, nearly black, exuvia central; bark infesting.

Genus **HEMIBERLESIA** Leonardi, 1897

Hemiberlesia Cockerell, ms.
Ferris, 1938:SII–232.

Key to the Species Recorded from Hawaii

1. Perivulvar pores absent....................**rapax** (Comstock).
   Perivulvar pores present.................................. 2
2. Second and third lobes unsclerotized points only; female scale circular, convex........................**lataniae** (Signoret).
   Second lobes well developed and sclerotized, third lobes sclerotized and distinct; female scale flat, elongate-oval... ....**cyanophylli** (Signoret).

Hemiberlesia cyanophylli (Signoret) (fig. 182).

Aspidiotus cyanophylli Signoret, 1869:119, pl. 3, fig. 11.

Ferris, 1938:SII–237.

Oahu, Hawaii.

Immigrant. Cosmopolitan. First listed from the Hawaiian Islands by Kotinsky in 1910 (p. 128).

Hostplants: avocado, banana, *Eugenia jambolana,* mango, sugarcane, "tou-tou," *Wistaria,* etc.

Parasites: *Aspidiotiphagus citrinus* (Craw), *Aphytis chrysomphali* (Mercet) (Hymenoptera: Aphelinidae); *Signiphora aspidioti* Ashmead (Hymenoptera: Signiphoridae).

Female scale elongate-oval, whitish or yellowish, exuvia central, yellow; on leaves.

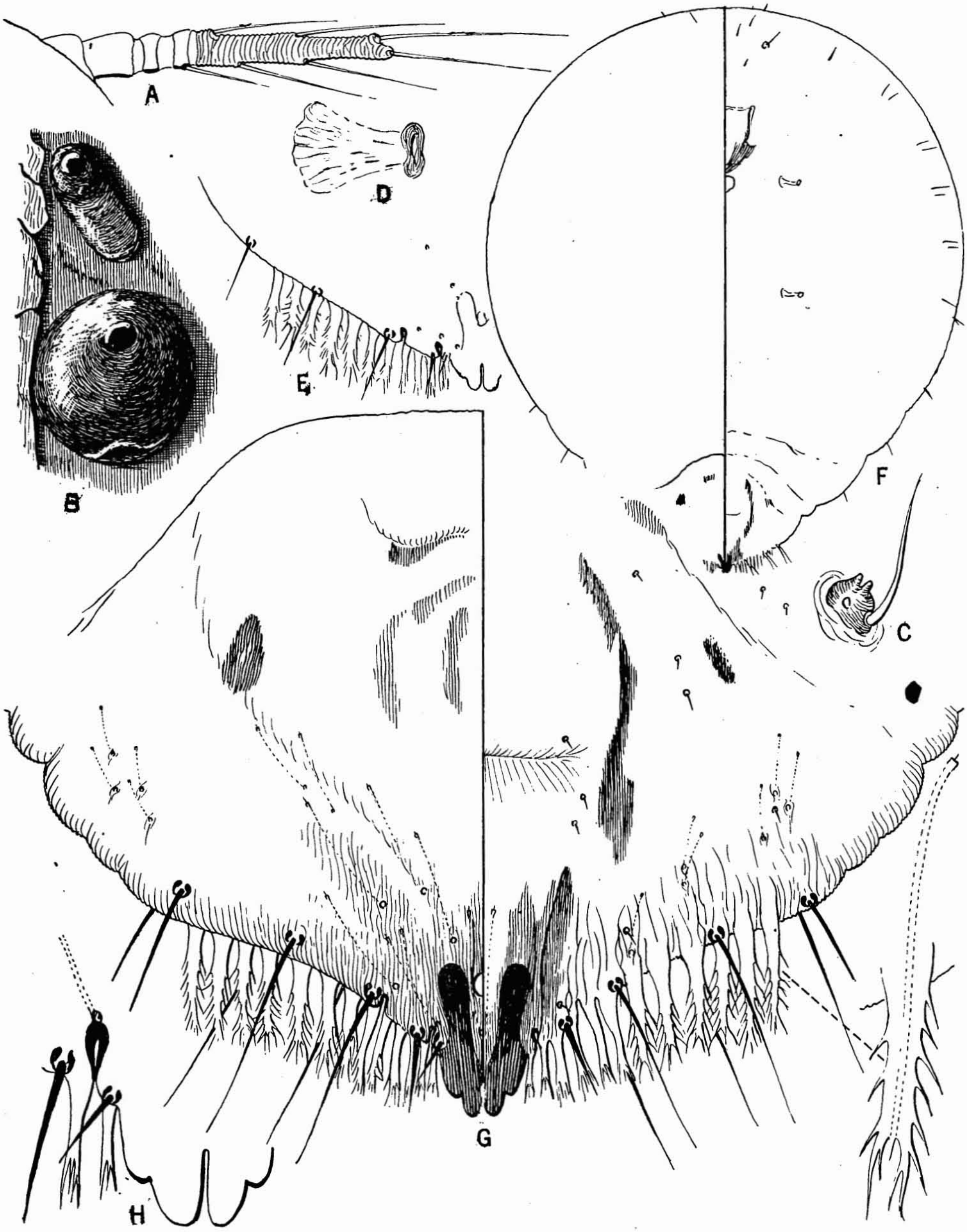


Figure 181—*Morganella longispina* (Morgan).

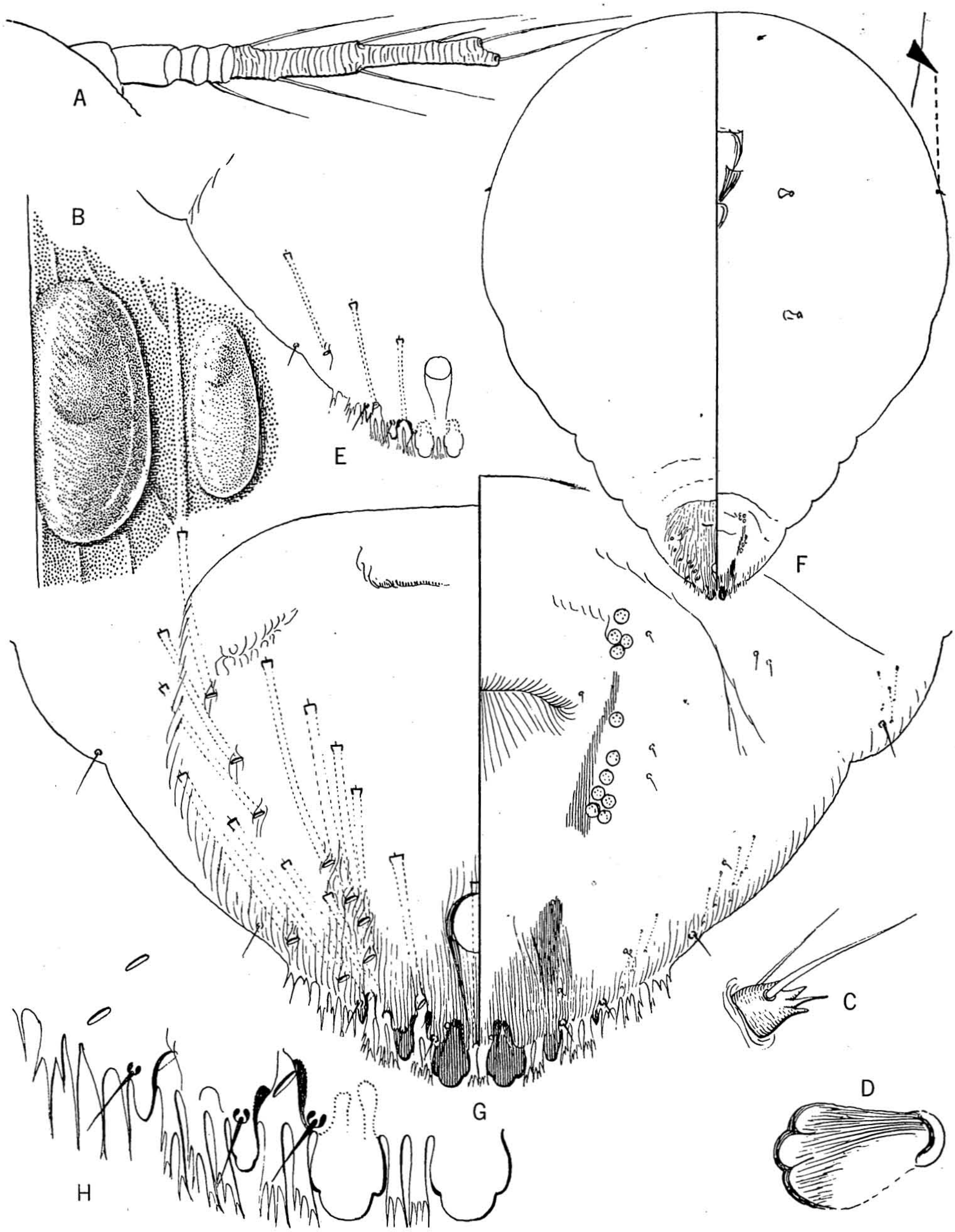


Figure 182—*Hemiberlesia cyanophylli* (Signoret).

Hemiberlesia lataniae (Signoret) (fig. 183).
Aspidiotus lataniae Signoret, 1869:124, pl. 3, figs. 12 and B.
Ferris, 1938:SII–241.

The latania scale.
Kauai, Oahu, Molokai, Maui.
Immigrant. Tropicopolitan. First found in Hawaii by Koebele (1898:109).
Hostplants: *Acacia farnesiana,* avocado, "conifer," cycad, *Freycinetia, Gladiolus,* guava, lantana, *Metrosideros, Muehlenbeckia platyclados,* "palms," *Pritchardia martii,* sugarcane, etc.
Parasites: *Aphytis diaspidis* (Howard), *Aphytis chrysomphali* (Mercet), *Prospaltella bicolor* Timberlake (Hymenoptera: Aphelinidae); *Signiphora aspidioti* Ashmead (Hymenoptera: Signiphoridae).
Female scale convex, white or yellowish or grayish; exuvia large, yellowish to dark, displaced to side; on bark, leaves or fruit.
This species has appeared in our literature as *Aspidiotus cydoniae* Comstock and *Aspidiotus cydoniae* variety *tecta* Maskell. It is considered to be probably the most serious pest of avocados in California (see Lindgren and McKenzie, 1936:369).
Some workers have confused the specific name *lataniae* (from *Latania,* a fan palm) with *Lantana,* the shrubby ornamental or weed.

Hemiberlesia rapax (Comstock) (fig. 184).
Aspidiotus rapax Comstock, 1881:307, pl. 12, fig. 6.
Aspidiotus camelliae Signoret, of authors.
Ferris, 1938:SII–244.

The greedy scale.
Kauai, Oahu, Maui.
Immigrant. First listed from Hawaii by Koebele (1898:109).
Hostplants: *Acacia koa,* apple, bamboo, *Citrus, Metrosideros,* peach, pear, etc.
Parasites: *Aphytis chrysomphali* (Mercet), *Pseudopteroptrix imitatrix* Fullaway, *Prospaltella bicolor* Timberlake (Hymenoptera: Aphelinidae); *Comperiella bifasciata* Howard (Hymenoptera: Encyrtidae).
Female scale circular, strongly convex, thin, grayish, about 1.2 mm. in diameter; exuvia at one side and giving a tipped-over appearance to the scale, grayish, brownish or yellowish; on bark, leaves or fruit. The body of the female is yellow.

Genus **AONIDIELLA** Berlese and Leonardi, 1895

See McKenzie, 1938:1–36, figs. 1–16.

Aonidiella inornata McKenzie (fig. 185).
Aonidiella inornata McKenzie, 1938:10, figs. 9, 10.

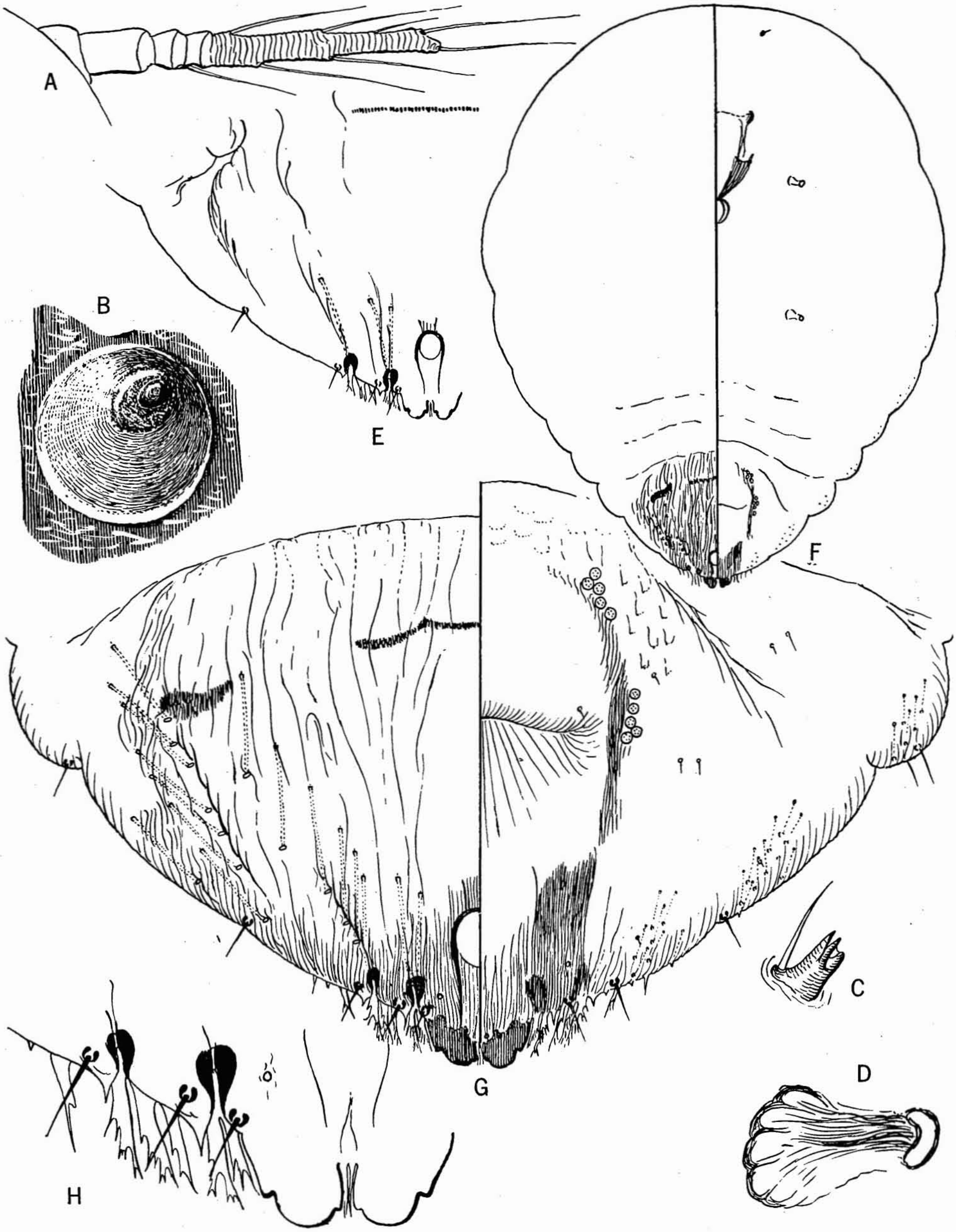


Figure 183—*Hemiberlesia lataniae* (Signoret), the latania scale.

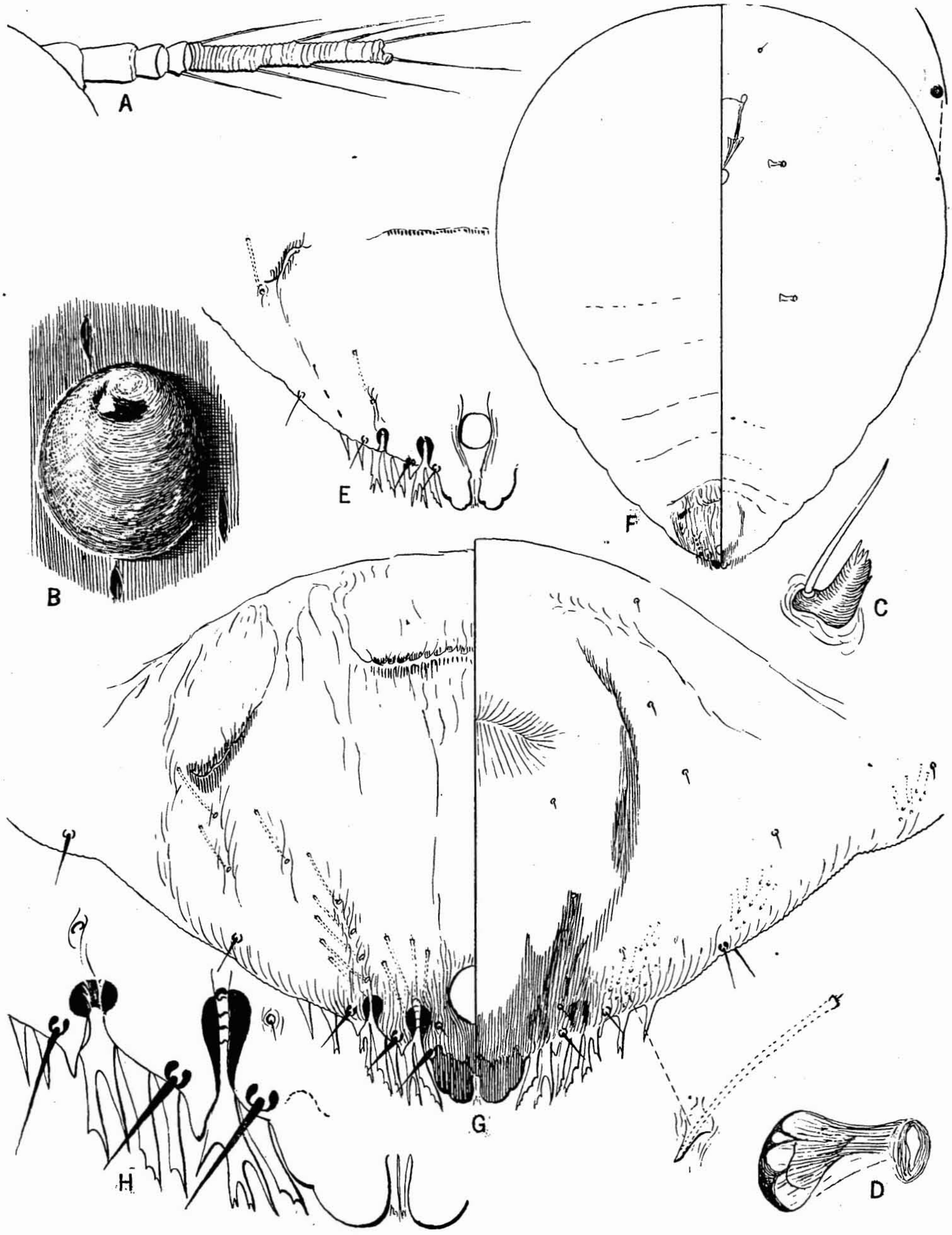


Figure 184—*Hemiberlesia rapax* (Comstock), the greedy scale.

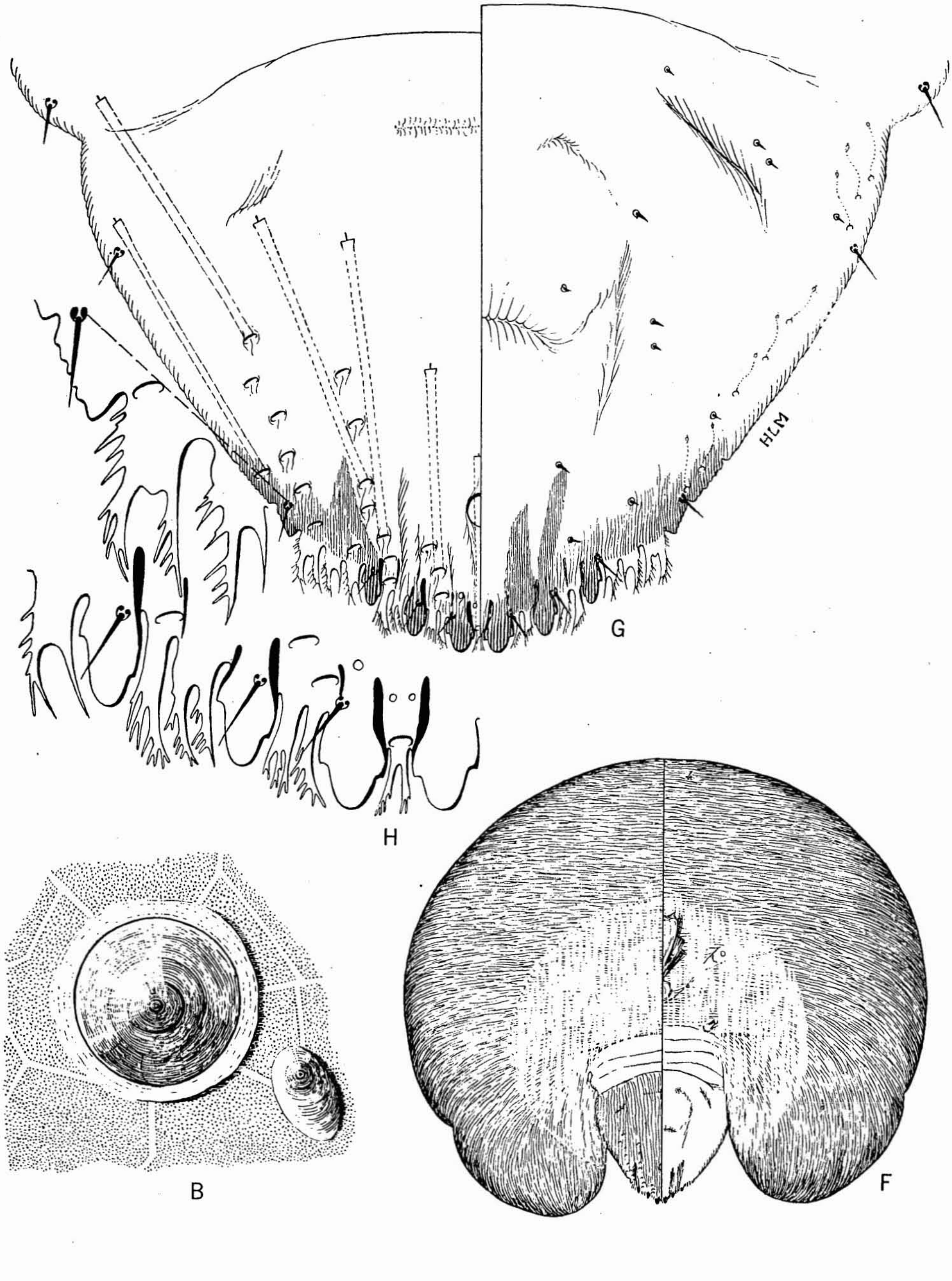


Figure 185—*Aonidiella inornata* McKenzie, the yellow scale. (Drawing loaned by McKenzie.)

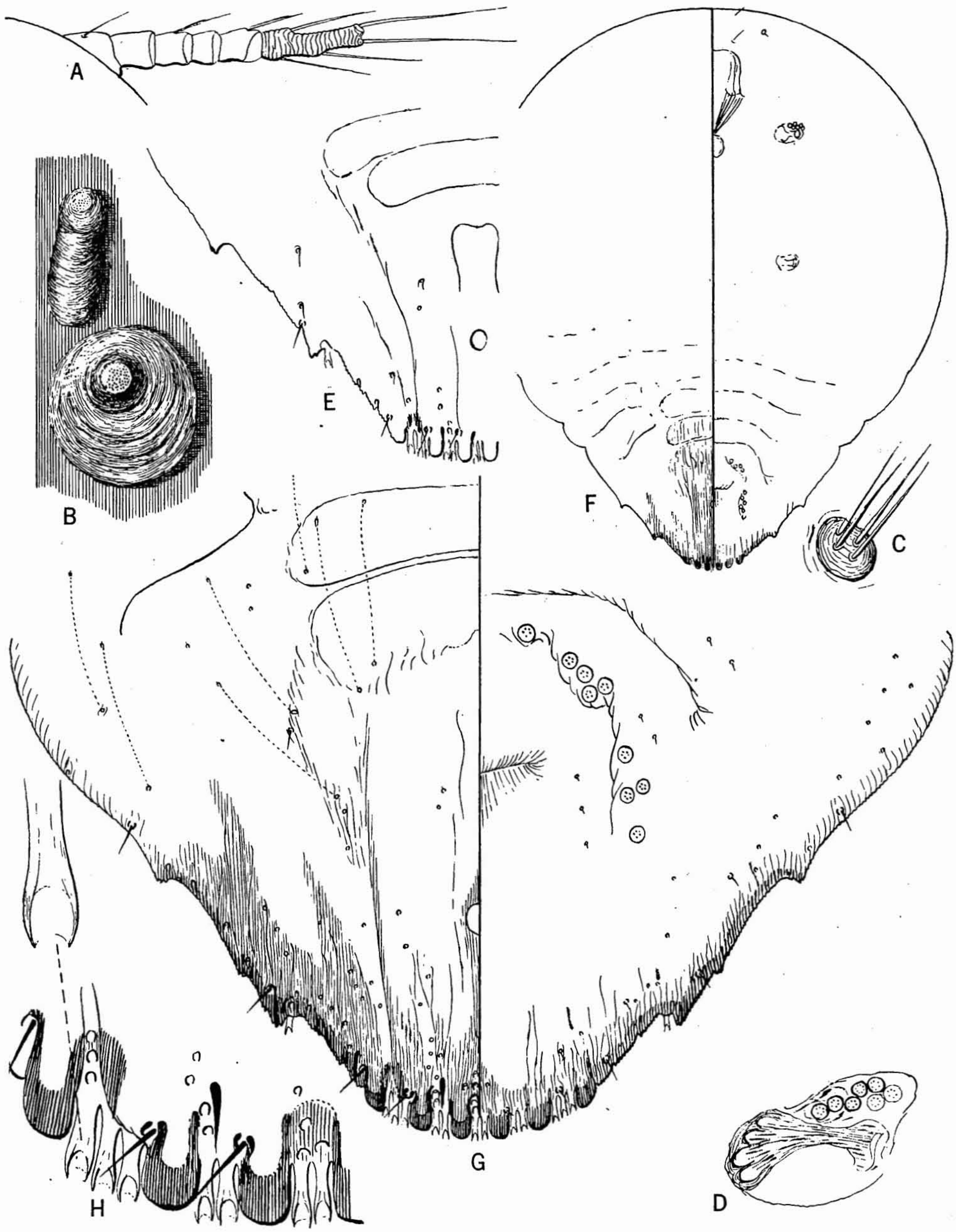


Figure 186—*Furcaspis biformis* (Cockerell), a large brown scale commonly found heavily infesting orchids.

The yellow scale.

Oahu.

Immigrant. Known elsewhere from China and the Philippines. First reported from the Hawaiian Islands by Maskell in 1895 (p. 2) as *Aspidiotus aurantii* Maskell.

Hostplants: coconut, *Cordyline terminalis* ("ti"), cycad, *Jasminum sambac,* oleander, orange, palm, *Piper* ("kawa"), sago.

Parasites: none has been recorded from it in Hawaii.

Female scale circular, exuvia central, yellowish-brown, translucent, outline of body showing through the scale.

The peculiar reniform shape of the body of the adult female, as illustrated, serves to distinguish this species readily from our other diaspids. It appears as if the pygidium has been abnormally pushed into the body. It has been confused in local literature (under the names *Aspidiotus* and *Chrysomphalus aurantii*) with the related genotype species *Aonidiella aurantii* (Maskell), the well-known "red scale."

Genus **FURCASPIS** Lindinger, 1908

Ferris, 1938:SII–230.

Furcaspis biformis (Cockerell) (figs. 186, 187).
Aspidiotus biformis Cockerell, 1893:548, fig. 81, 4.
Ferris, 1938:SII–231.

Oahu.

Immigrant. A widespread species evidently first listed from Hawaii by Fullaway in 1938 (*Proc. Hawaiian Ent. Soc.* 10(1):46).

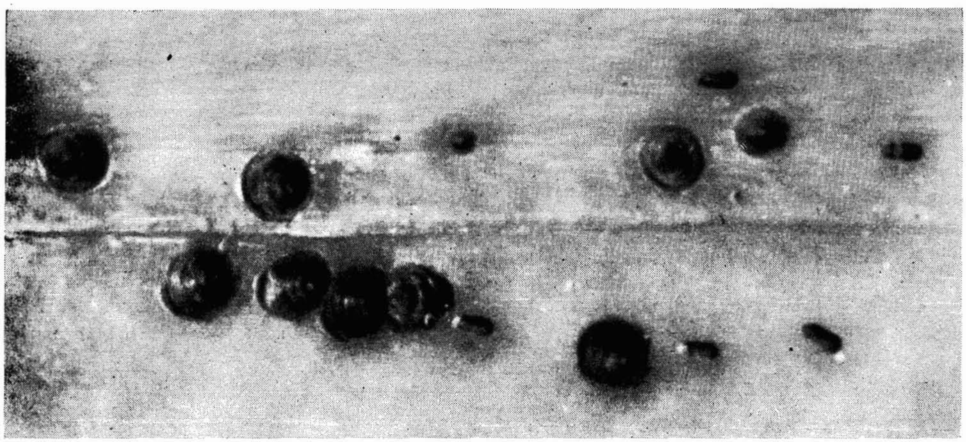


Figure 187—*Furcaspis biformis* (Cockerell).

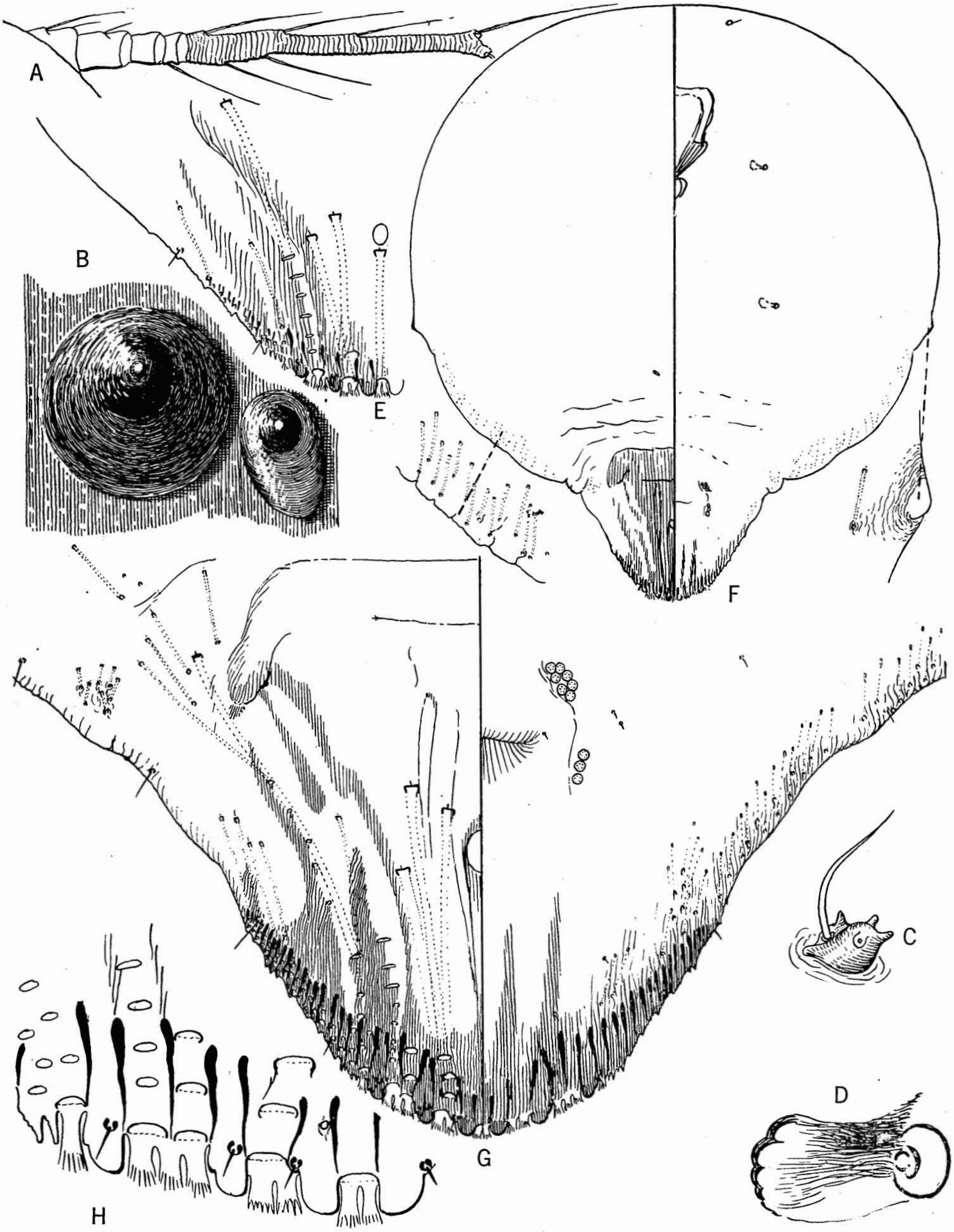


Figure 188—*Lindingaspis rossi* (Maskell).

Hostplants: orchids of several genera (damages some species), *Cattleya, Vanda.*

Female scale circular, reddish brown; exuvia central; male scales similar in color, but narrow. It is a large (up to 2.5 mm. in diameter), easily recognized scale which may plaster orchids both in orchid houses and out of doors. Nicotine sprays are useful in controlling it. Although the scales may be killed, the dead bodies may adhere to the plants.

Genus **LINDINGASPIS** MacGillivray, 1921:388

Ferris, 1938:SII–245.

Lindingaspis rossi (Maskell) (fig. 188).

Aspidiotus rossi Maskell, 1890:3.

Chrysomphalus rossi (Maskell), of authors.

Ferris, 1938:SII–246.

Oahu.

Immigrant. A widespread species, described from Australia, and first listed from the Hawaiian Islands by Kotinsky (1910:129).

Hostplants: *Araucaria bidwillii,* orchids.

Parasites: *Aspidiotiphagus citrinus* (Craw), *Aphytis chrysomphali* (Mercet) (Hymenoptera: Aphelinidae).

Female scale circular, flat, dark brown to black; exuvia dark, nearly central.

Genus **CHRYSOMPHALUS** Ashmead, 1880

Ferris, 1938:SII–198.

McKenzie, 1939:51–77, figs. 26–35, revision; 1943:149–150, revised key to the 10 known species.

Key to the Species Known in Hawaii

(Modified from McKenzie.)

1. At least one prepygidial abdominal segment with a submarginal, dorsal cluster of ducts 2
   Prepygidial abdominal segments with at most three or four marginal ducts, not with a submarginal, dorsal cluster... 3

2(1). Abdominal segments 2 and 3 each with a dorsal submarginal cluster of ducts................**bifasciculatus** Ferris.
   Only second abdominal segment with a dorsal submarginal cluster of ducts..........................**ficus** Ashmead.

3(1). First two plates anterior to third pygidial lobe each with a conspicuous clavate and at most but slightly fringed process........................**dictyospermi** (Morgan).
First two plates anterior to third lobe variously fringed but never with conspicuous clavate processes.............
..................................**propsimus** Banks.

Chrysomphalus bifasciculatus Ferris (fig. 189).
Chrysomphalus bifasciculatus Ferris, 1938:SII–199.

Oahu.

Immigrant. A widespread species, evidently of Oriental origin. First listed from Hawaii by Ferris (1938:SII–199).

Hostplant: none recorded in Hawaii.

Female scale flat, circular, dark brown; exuvia paler, subcentral.

Chrysomphalus dictyospermi (Morgan) (fig. 190).
Aspidiotus dictyospermi Morgan, 1889:352, pl. 5, fig. 2.
Ferris, 1938:SII–200.

Oahu.

Immigrant. Tropicopolitan; described from Demerara, British Guiana. First recorded from the Hawaiian Islands by Kotinsky (1910:129).

Hostplants: almond, *Anthurium,* ferns, mango, palms, sago, *Verschaffeltia splendida.*

Female scale flat, thin, circular, yellowish or pale brown; exuvia central.

Chrysomphalus ficus Ashmead (fig. 191).
Chrysomphalus ficus Ashmead, 1880:267, 1 fig. Genotype. Ferris, 1938:SII–201.
Chrysomphalus aonidum (Linnaeus), of authors.

The Florida red scale.

Oahu, Molokai, Maui.

Immigrant. Cosmopolitan; described from orange from Florida. Apparently first listed from Hawaii by Kotinsky in 1907 (*Proc. Hawaiian Ent. Soc.* 1(3):83).

Hostplants: *Aleurites moluccana* ("kukui," candlenut), *Anthurium,* breadfruit, *Cerasus, Citrus,* coconut, cycad, *Dendrobium, Eugenia jambolana, Latania* (fan palm) leaflets, mango, oleander, "palm," *Pandanus,* sago, *Strelitzia reginae.*

Parasites: *Aphytis chrysomphali* (Mercet), *Aspidiotiphagus citrinus* (Craw) (Hymenoptera: Aphelinidae).

Predator: *Curinus coeruleus* (Mulsant) (Coleoptera: Coccinellidae).

Female scale circular, flat, dark; exuvia paler, central; on leaves.

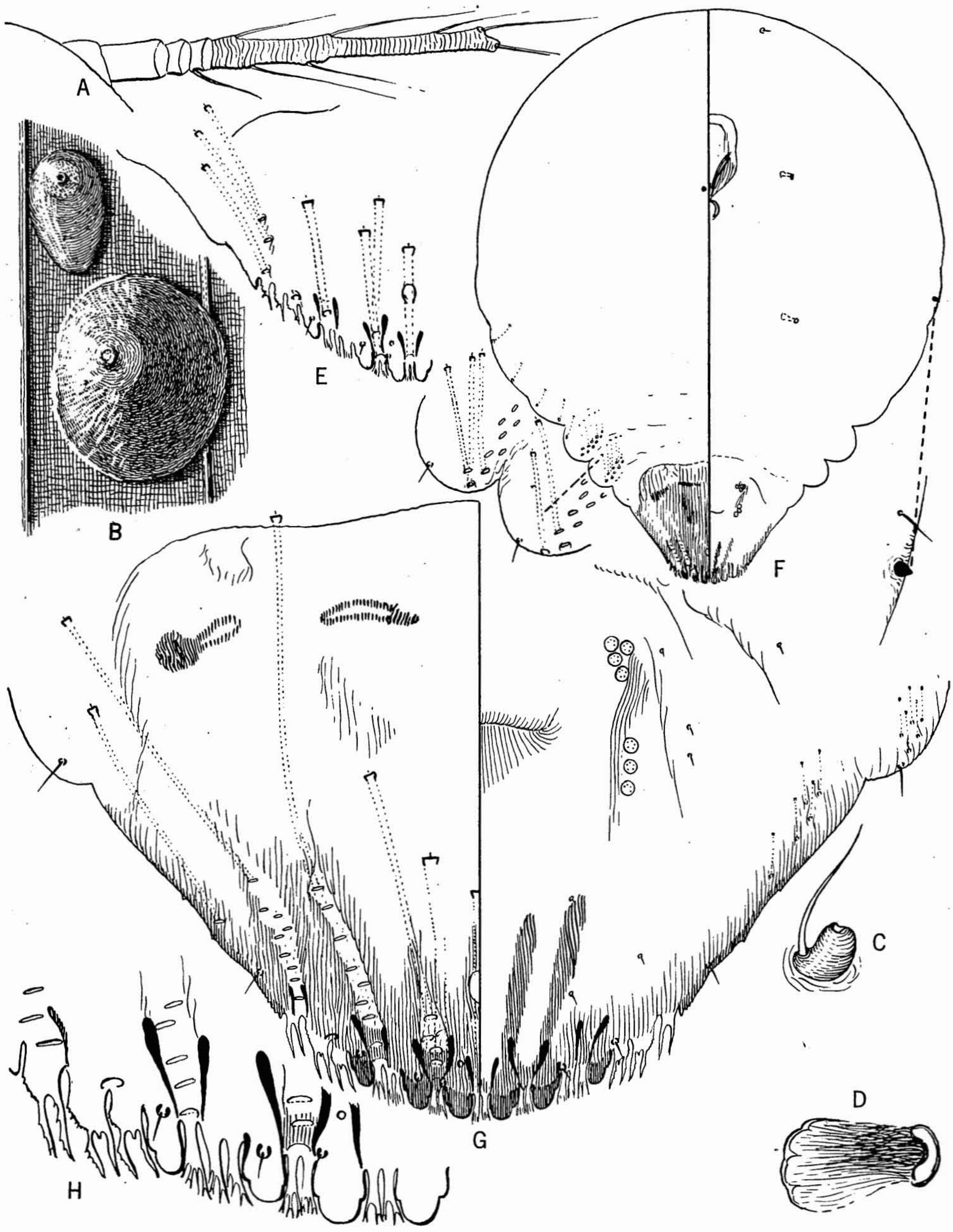


Figure 189—*Chrysomphalus bifasciculatus* Ferris.

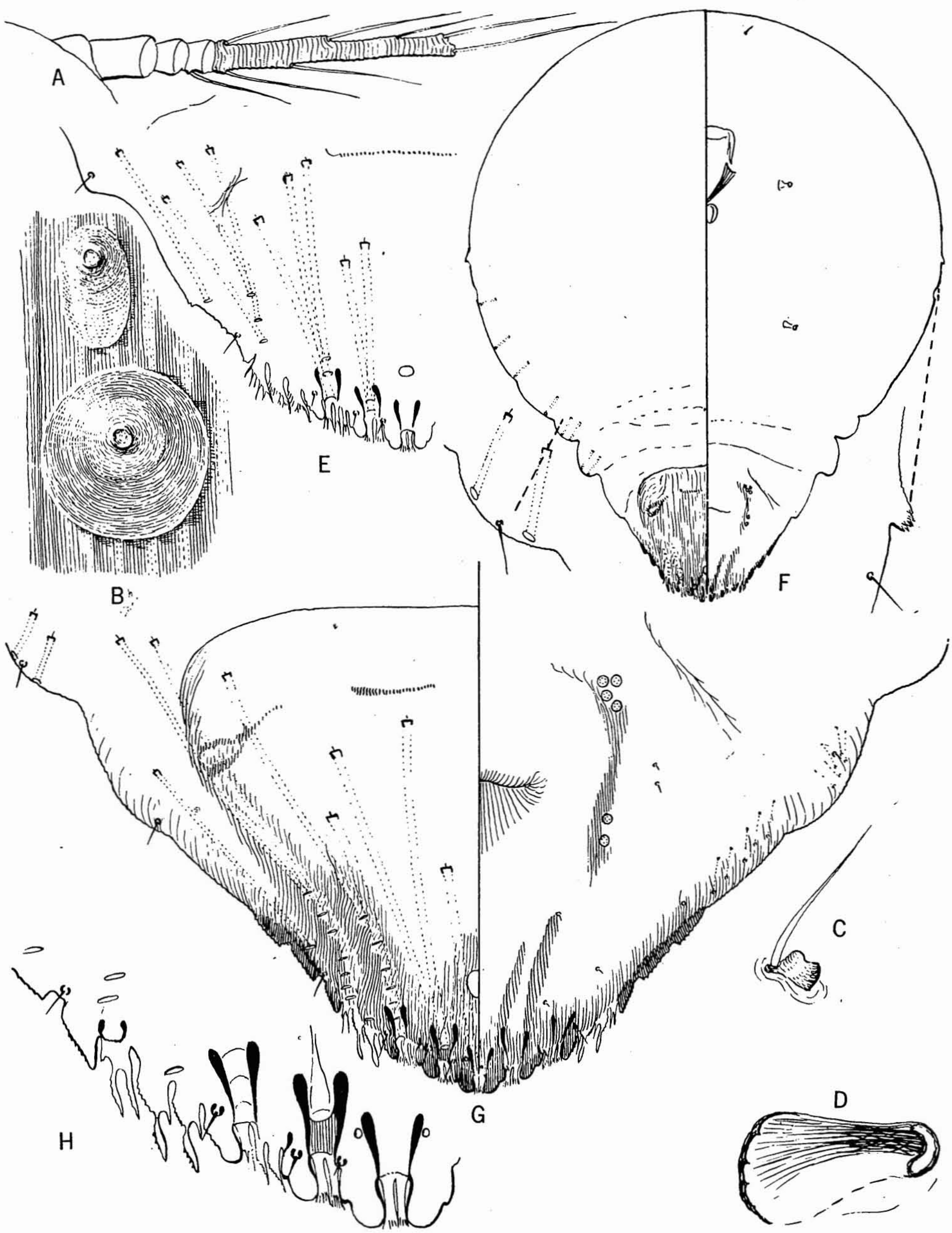


Figure 190—*Chrysomphalus dictyospermi* (Morgan).

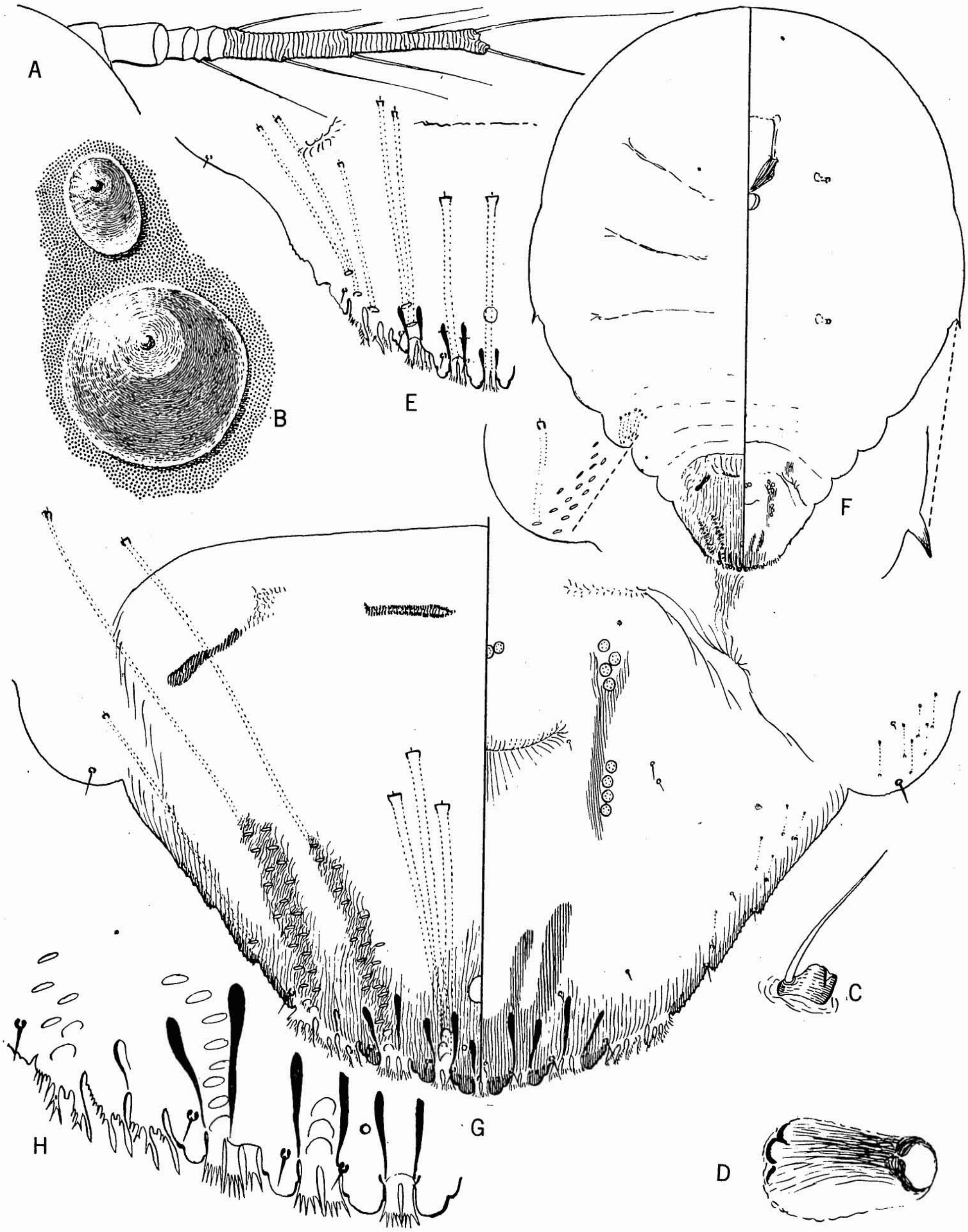


Figure 191—*Chrysomphalus ficus* Ashmead, the Florida red scale.

Chrysomphalus propsimus Banks.

Chrysomphalus propsimus Banks, 1906:230, pls. 1–2.

McKenzie, 1939:62–63, fig. 33.

Oahu.

Immigrant. A Philippine species, described from Manila. First found in Hawaii by me at Honolulu in 1945 (identified by Harold Morrison).

Hostplant: *Pandanus* (known also from coconut, *Calamus spectabilis* and *Corypha elata* in the Philippines).

"Occurring on the leaves. Scale of female dark chocolate color, flat and circular, exuvia subcentral; scale of the male similar in color, oval, exuvia toward one end." (McKenzie, 1939:62.)

Tribe DIASPIDINI

Key to the Genera Recorded from Hawaii

(Recast from Ferris.)

Adult Females

1. Entirely enclosed within exuvia of preceding stage....... 2
   Not enclosed within exuvia of preceding stage........... 3

2(1). Disc pores present on at least one segment anterior to and in addition to usual perivulvar pores; antennae minute; median pygidial lobes not zygotic.......... ....**Leucodiaspis** Signoret.
   With no disc pores other than usual perivulvar groups or a transverse row anterior to vulva; antennae unusually large, situated close together at anterior edge of head; median pygidial lobes zygotic............... ....**Fiorinia** Targioni-Tozzetti.

3(1). Median lobes present, yoked basally by an internal sclerosis.. 4
   Median lobes present or absent; if present, not yoked basally by an internal sclerosis.................... 6

4(3). Prosoma swollen, more or less quadrate, wider than postsoma, sides of postsoma roughly parallel; pygidial lobes forming a distinct notch in apex of pygidium... ....**Aulacaspis** Cockerell.
   Body not so formed.................................. 4*a*

4*a*(4). Body broadly turbinate; median lobes large and prominent.....................**Pseudaulacaspis** MacGillivray.
   Body fusiform, prosoma tapering anteriorly; median lobes various 5

5(4). Median lobes of pygidium divergent, thus forming a distinct notch in pygidium......................... ....**Phenacaspis** Cooley and Cockerell.
   Median lobes of pygidium continuous or partially or entirely fused, pygidium thus without a median notch as in *Phenacaspis*.....................**Pinnaspis** Cockerell.

6(3). Marginal pygidial macroducts with axis of their orifices set transversely or essentially so, each with orifice surrounded by a transversely oval, sclerotized rim........ 7

Marginal pygidial macroducts with axis of their orifices set longitudinally or diagonally, sclerotized rim, if present, similarly placed........................... 8

7(6). Perivulvar pores lacking; prosoma and apical half of pygidium becoming very heavily sclerotized at maturity; gland spines laterally serrate; as far as known restricted to orchids.........**Genaparlatoria** MacGillivray.

Perivulvar pores present; prosoma not sclerotized at maturity; gland spines variable, fimbriate or toothed ....**Parlatoria** Targioni-Tozzetti.

8(6). Dorsum of pygidium with sclerotization forming a coarse reticulate pattern...................**Ischnaspis** Douglas.

Pygidium without such reticulation.................. 9

9(8). With an elongate, club-shaped, internal, sclerotized process arising from base of each median lobe............10

Without such a structure, or if it is present, a similar structure arises from base of each second lobe also.....11

10(9). Body slenderly fusiform and membranous at maturity; perivulvar pores present..........**Andaspis** MacGillivray.

Body broadly turbinate; dorsum as far posteriorly as first abdominal segment strongly sclerotized at maturity; perivulvar pores absent.........................
......................**Howardia** Berlese and Leonardi.

11(9). Margin of pygidium with membranous, low, broad, apically serrate processes in addition to lobes and gland spines; occurring, as far as known, only on bamboos..
.... **Kuwanaspis** MacGillivray.

Margin of pygidium not so formed....................12

12(11). Body turbinate, prosoma obviously broader than postsoma; anus posterior to middle of pygidium or at about middle ....**Diaspis** Costa.

Body fusiform, elongate, postsoma obviously broader than prosoma; anus anterior to middle of pygidium...
.... **Lepidosaphes** Shimer.

Genus **LEUCODIASPIS** Signoret, 1869

Leucaspis Targioni-Tozzetti, 1868, not Burmeister, 1835.
Ferris, 1938: SII–147.

Leucodiaspis cockerelli (de Charmoy) (figs. 192, 193).

Fiorinia cockerelli de Charmoy, Proc. Société Amicale Scientifique, 1899:33 (I have not seen this reference).

Leucaspis cockerelli (de Charmoy), Ferris, 1941 :SIII–289.

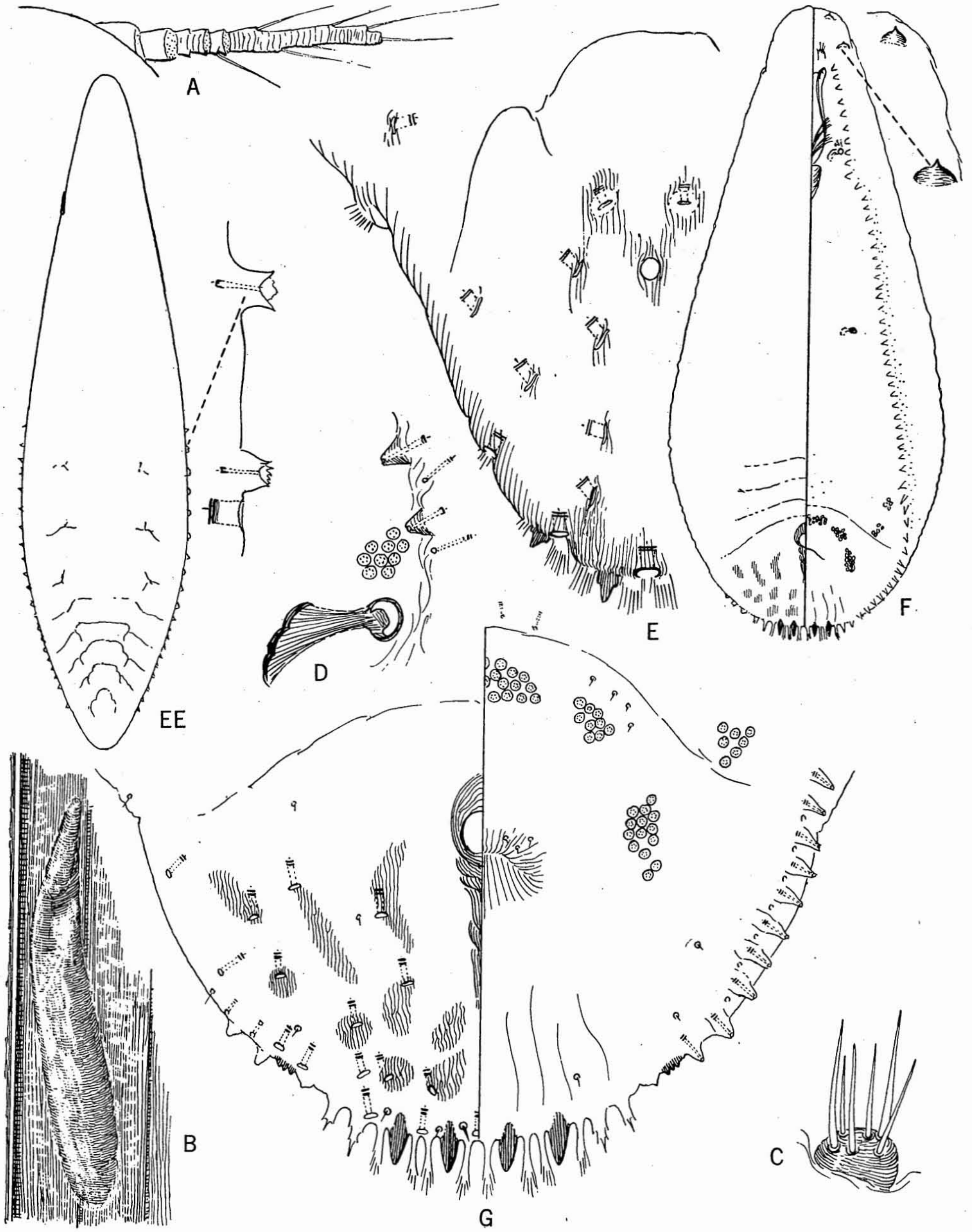


Figure 192—*Leucodiaspis cockerelli* (de Charmoy).

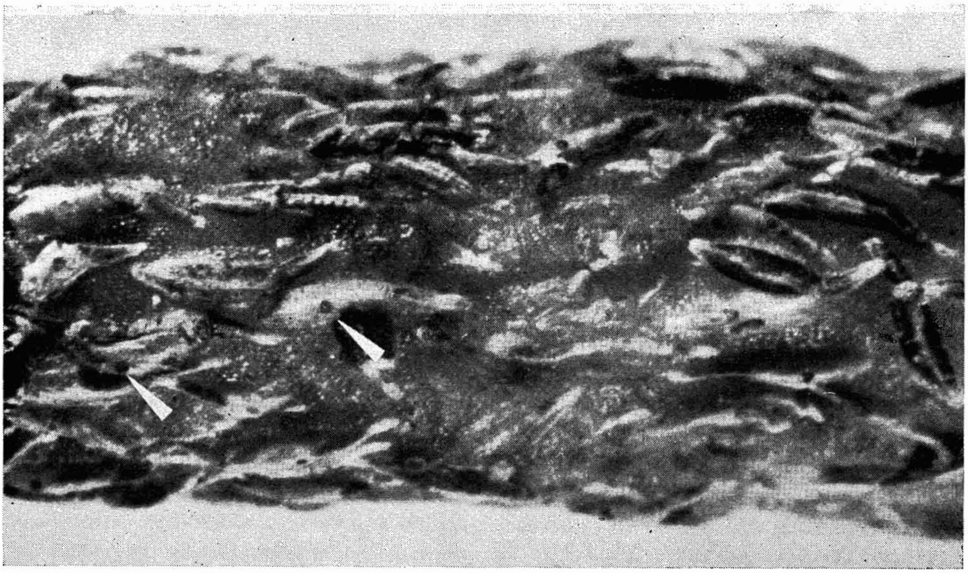


Figure 193—*Leucodiaspis cockerelli* (de Charmoy) on a shoot of *Vanda* orchid. The arrows point to exit holes made by the minute eulophid parasite *Aspidiotiphagus agilior* Berlese, which is only 0.25 mm. in length.

Oahu, Hawaii.

Immigrant. A widespread species from Africa to America. First listed from the Hawaiian Islands by Pemberton in 1934.

Hostplants: orchids, *Vanda, Thuya orientalis.*

Parasite: *Aspidiotiphagus agilior* Berlese (Hymenoptera: Aphelinidae).

Scale very long and slender, brown; an unusual-looking scale and easily recognized. It may mass on its host (as the figure shows) and may cause serious injury or death to its host tissue. Orchid shoots may be discolored, turn red, then blackish and die.

The species listed by Fullaway (1932:113) as *Leucaspis indica,* now known as *Radionaspis indica* (Marlatt) Ferris, is not known to be established here. It was intercepted on Indian mangos in quarantine.

Genus **FIORINIA** Targioni-Tozzetti, 1868

Fiorina (Targioni-Tozzetti) Signoret, 1869.
Ferris, 1937:SI–54.

Key to the Species Reported from Hawaii

1. Perivulvar pores present (on avocado and *Macadamia*) .... **fioriniae** (Targioni-Tozzetti).
2. Perivulvar pores absent (on litchi) .... **nephelii** Maskell.

Fiorinia fioriniae (Targioni-Tozzetti) (fig. 194).
Diaspis fioriniae Targioni-Tozzetti, 1867:14.
Genotype of *Fiorinia.*
Ferris, 1937:SI–55.

The avocado scale.
Oahu.
Immigrant. Evidently an Oriental species, but now widespread. It is difficult to ascertain when the first record of this species was made in the Hawaiian Islands, because many of the records applied to this name prior to 1916 really belong to *Pinnaspis buxi.* However, it was apparently known to Koebele in 1896.
Hostplants: avocado, *Diospyros ferrea, Macadamia, Pritchardia* (?).
Parasite: *Aspidiotiphagus agilior* Berlese (Hymenoptera: Aphelinidae).
Female scale (the large second exuvium) elongate, flat, rather translucent brownish; first exuvium terminal.
In some of our literature this species is listed under the synonymous names of *Fiorinia pellucida* Targioni-Tozzetti and *Fiorinia camelliae* (Comstock).

Fiorinia nephelii Maskell (fig. 195).
Fiorinia nephelii Maskell, 1897:242.

Oahu.
Immigrant. A rather widespread species described from China, Formosa and Australia. First listed from the Hawaiian Islands by Fullaway (1932:94).
Hostplant: litchi.
Female scale (the large second exuvium) elongate, yellowish; first exuvium dark, terminal.

Genus **AULACASPIS** Cockerell, 1893

Ferris, 1937:SI–9.

Professor Ferris has supplied the following note and key:
The genus *Aulacaspis* is a large group with perhaps as many as 30 reputed species, all of which seem to belong to the Oriental Region. No review of the group exists and the identification of species will remain quite doubtful until such a review has been made.

Key to the Species of Aulacaspis Recorded from Hawaii

1. Dorsum of abdomen with but four rows of ducts, counting forward from row of ducts immediately flanking anal opening..**rosae** (Bouché).
2. Dorsum of abdomen with 10 rows of ducts, counting forward from row flanking anal opening...........**fulleri** (Cockerell).

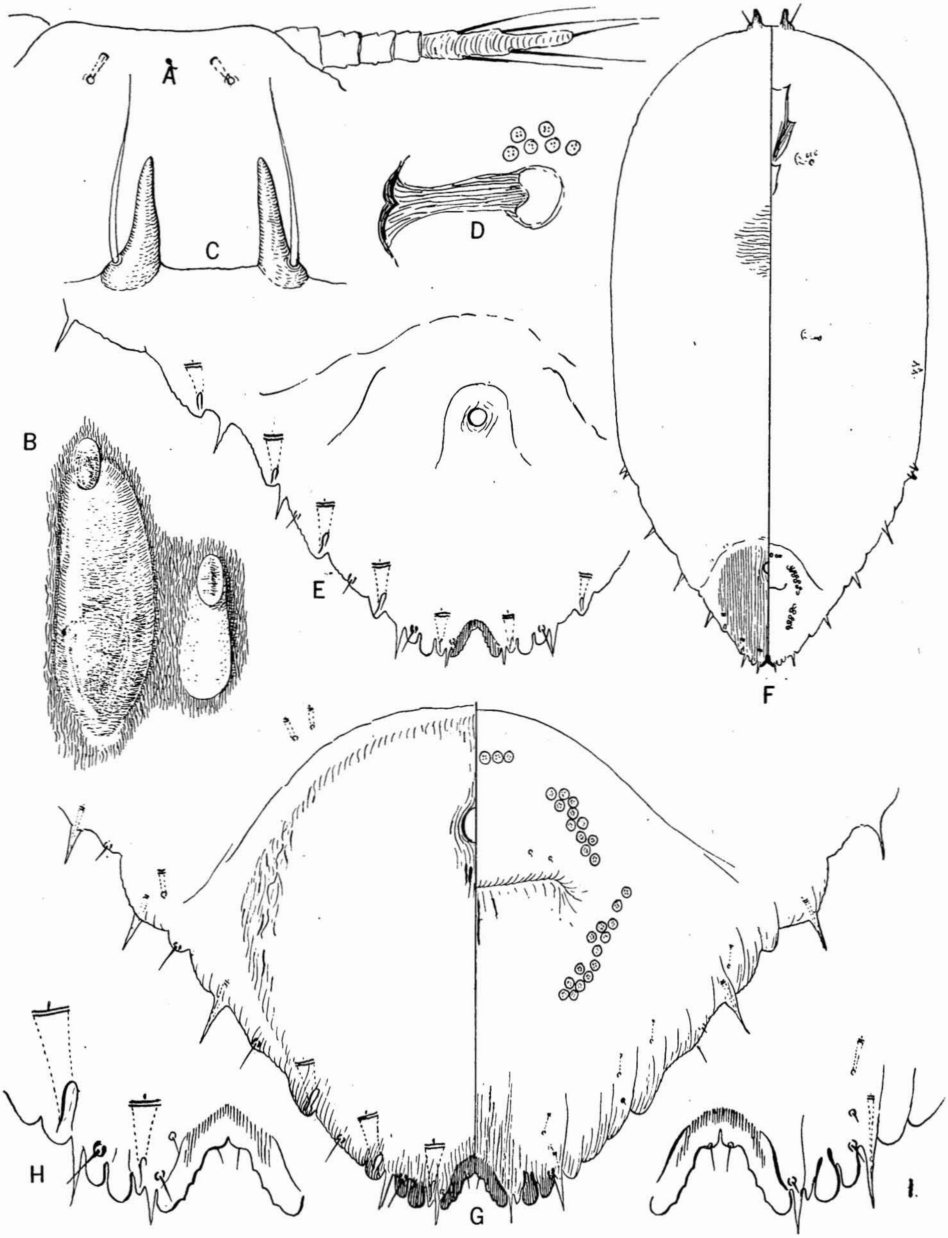


Figure 194—*Fiorinia fioriniae* (Targioni-Tozzetti), the avocado scale.

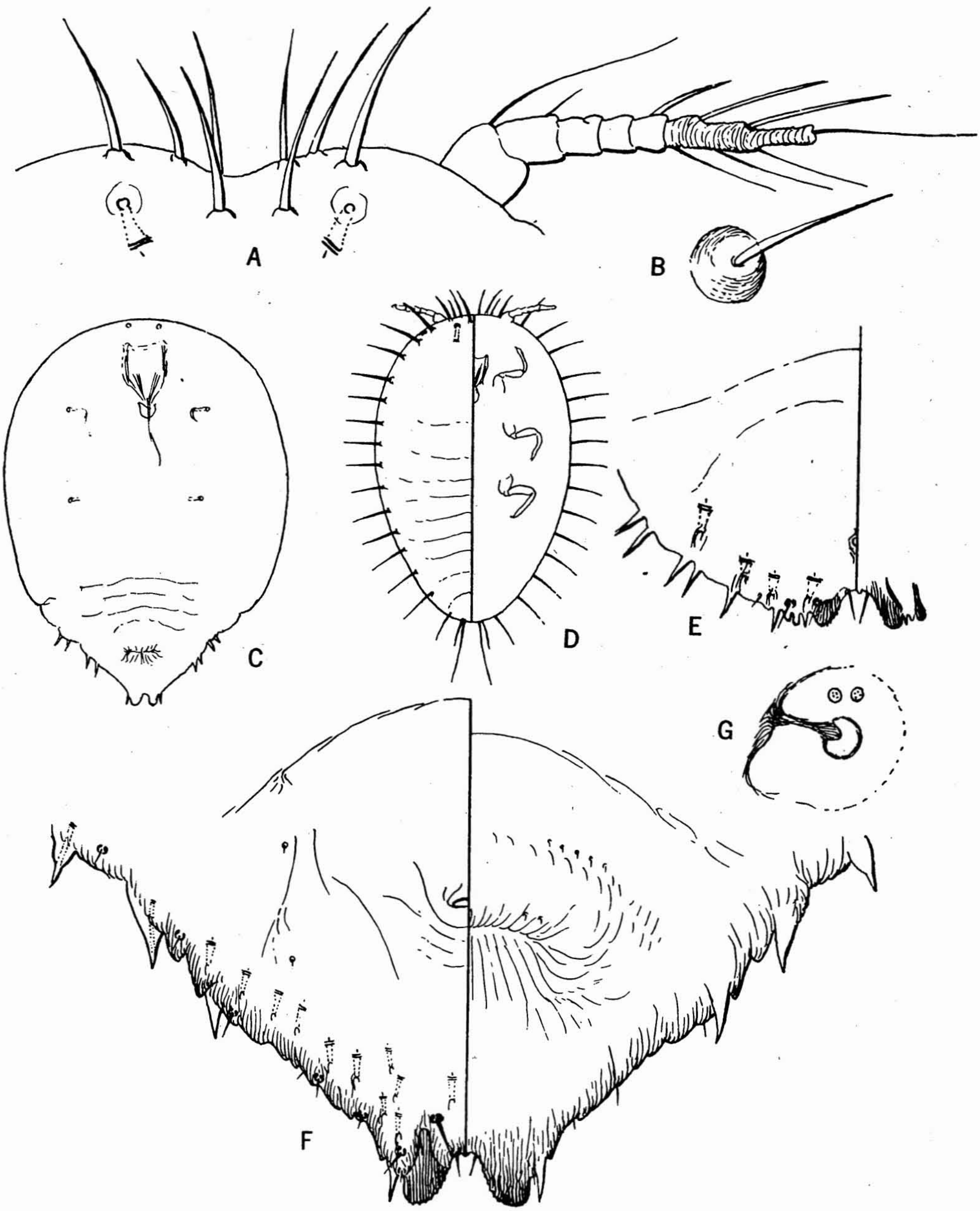


Figure 195—*Fiorinia nephelii* Maskell. Drawn from type material.

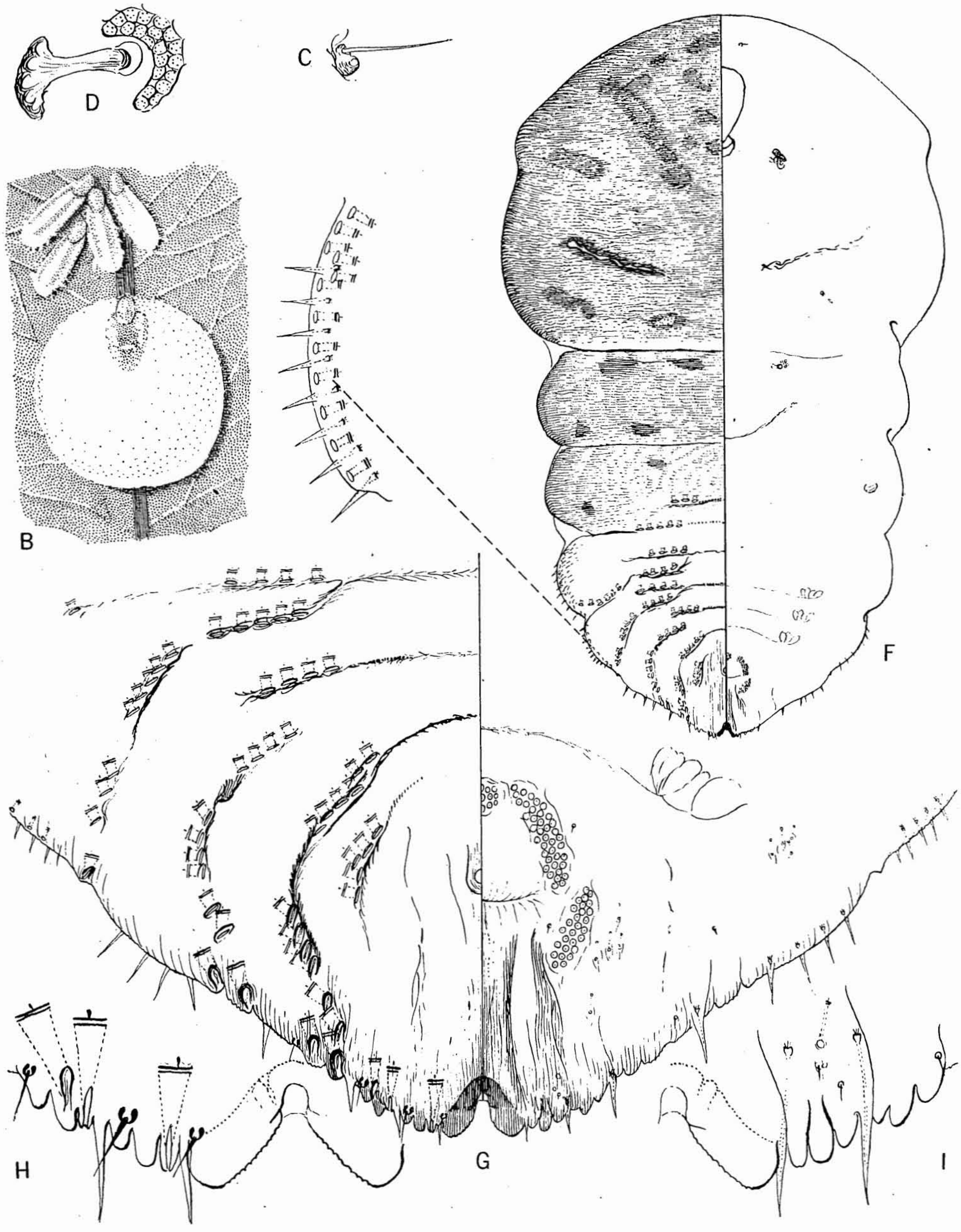


Figure 196—*Aulacaspis fulleri* (Cockerell).

Aulacaspis fulleri (Cockerell) (fig. 196).
Diaspis crawii variety *fulleri* Cockerell, 1901:225.

Oahu.
Immigrant. Described from South Africa. First recorded from the Hawaiian Islands by Giffard and Cockerell in 1925 (*Proc. Hawaiian Ent. Soc.* 6 (1):22). The original Hawaiian collection of this species was determined by Laing at the British Museum.
Hostplant: *Aglaia odorata* (material illustrated).

Aulacaspis rosae (Bouché) (fig. 197).
Aspidiotus rosae Bouché, 1834:14 (I have not seen this reference). Genotype of *Aulacaspis*.
Ferris, 1937:SI–10.

The rose scale.
Kauai, Oahu, Molokai, Maui, Hawaii.
Immigrant. Cosmopolitan. First listed from the Hawaiian Islands by Maskell in 1895 (p. 5) from specimens collected by Koebele.
Hostplant: rose.
Parasites: *Aphytis diaspidis* (Howard), *Aspidiotiphagus citrinus* (Craw) (Hymenoptera: Aphelinidae).
Predator: *Lindorus lophanthae* (Blaisdell) (Coleoptera: Coccinellidae).
Female scale white or grayish, flat, circular, about 1 mm. in diameter; exuvia subcentral; male scale white, narrow, tricarinate. The bodies of the living insects range from orange to dark red in color; the eggs are yellow.

Genus **PSEUDAULACASPIS** MacGillivray, 1921

Ferris, 1937:SI–108.

Pseudaulacaspis major (Cockerell) Ferris, new combination (fig. 198).
Chionaspis major Cockerell, 1894:43.
Aulacaspis major (Cockerell), of authors.
Aulacaspis flacourtiae Rutherford, 1915:259.
Diaspis (*Aulacaspis*) *flacourtiae* (Rutherford) Green and Laing, 1921:128, fig. 4.

Oahu.
Immigrant. Described from the West Indies. First listed from the Hawaiian Islands by Fullaway (1932:94).
Hostplants: litchi, longan.
Professor Ferris adds the following commentary:

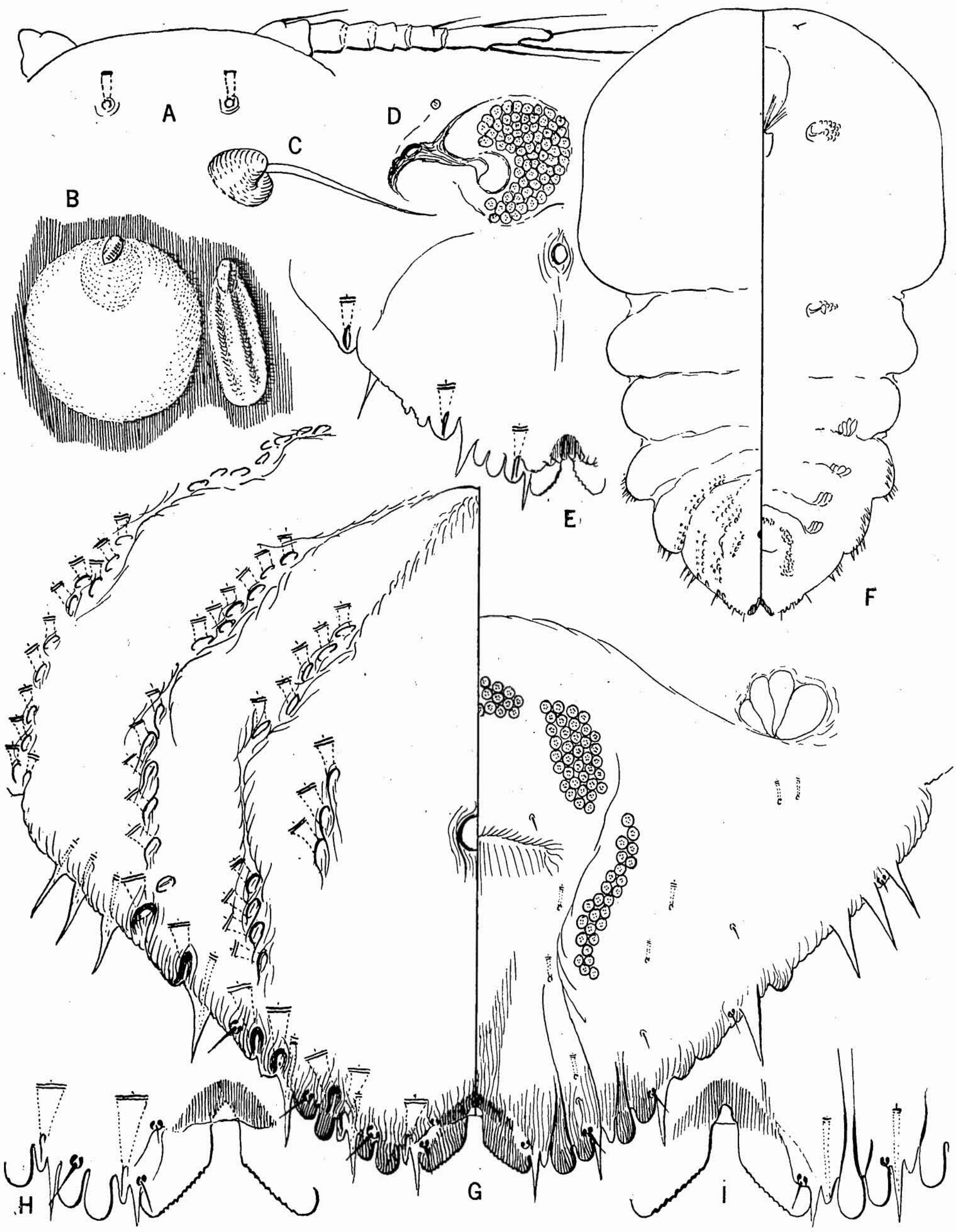


Figure 197—*Aulacaspis rosae* (Bouché), the rose scale.

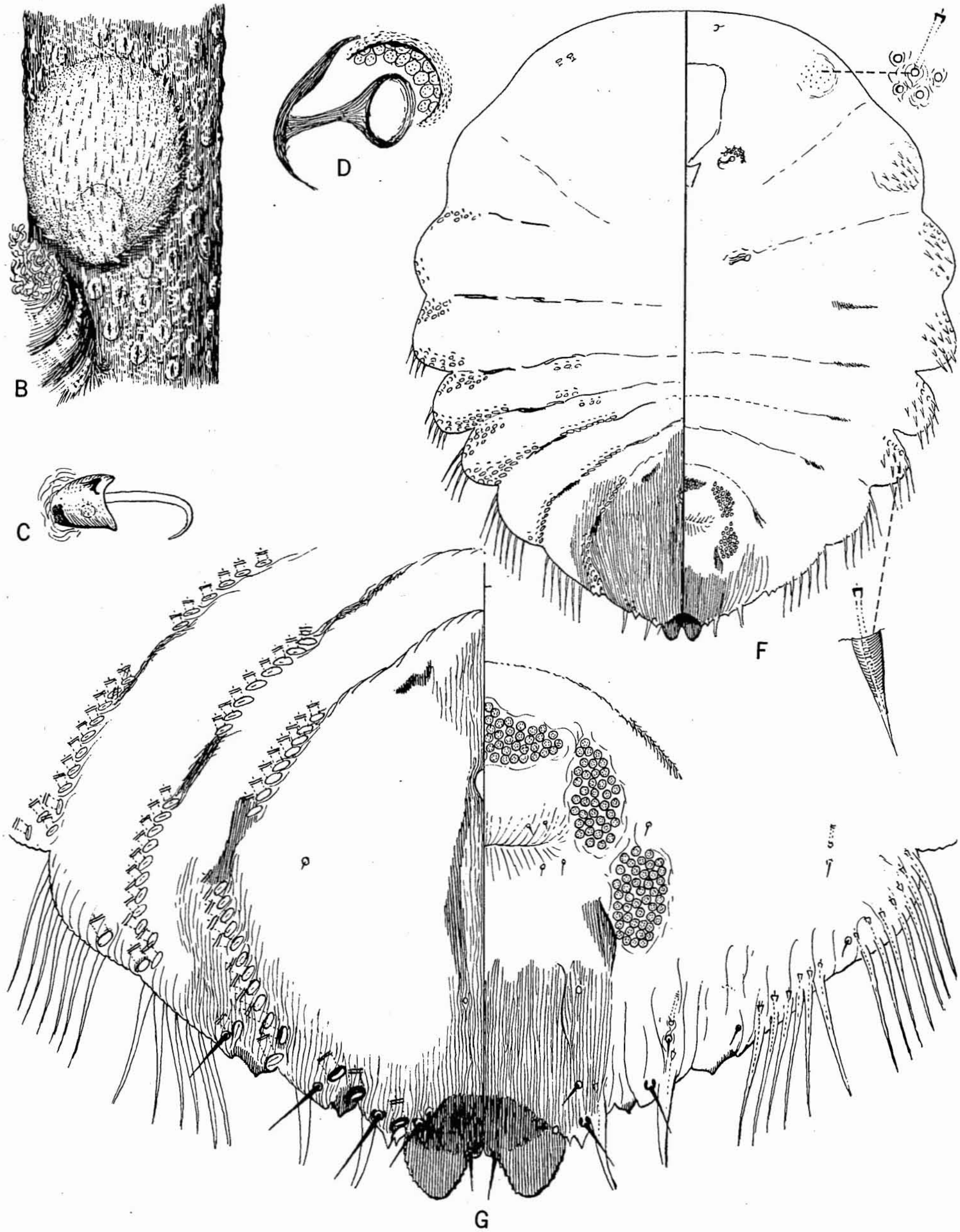


Figure 198—*Pseudaulacaspis major* (Cockerell). (Drawn for this text by Ferris.)

The accompanying figures are based upon specimens from *Litchi* at Honolulu, October 20, 1945, E. C. Zimmerman, collector.

This species is definitely referable to *Pseudaulacaspis,* although placing it here will require some slight modification of the diagnosis of the genus as given in the *Atlas of the Scale Insects of North America,* the statement concerning the pygidial lobes being modified to read, "second lobes small but distinct and bilobed, or reduced to mere points."

Green and Laing have redescribed *Diaspis flacourtiae* Rutherford, which is recorded from *Flacourtia* in Ceylon; and on the basis of this redescription and its accompanying illustration it seems clear that it is identical with the specimens at hand from Hawaii.

This species and the widely spread *Pseudaulacaspis pentagona* (Targioni) may be separated by the following key:

1. Second pygidial lobe definitely developed, distinctly bilobed; ducts near bases of these and third lobes without a sclerotized oral rim........................**pentagona** (Targioni).
2. Second pygidial lobe reduced to a mere point and lacking outer lobule; ducts near base of this and third lobe with a sclerotized oral rim.......................**major** (Cockerell).

Genus **PHENACASPIS** Cooley and Cockerell, 1899

Ferris, 1937:SI–91.

Except for a few representatives in North America, the genus *Phenacaspis* is Oriental. It apparently includes a considerable number of species, most of which in the past have been referred to *Chionaspis.* No review of the entire group has ever been made and at the present time we have little understanding of it. Consequently identifications are for the most part untrustworthy. The material at hand indicates that the separation of the species will probably be extremely difficult and will require a large amount of careful work before any improvement of the existing situation can be achieved.

Specimens of *Phenacaspis sandwicensis* (Fullaway) from oleander at Honolulu, March, 1942, collected by E. C. Zimmerman, are at hand and have been used as the basis of the accompanying illustrations.

On the basis of these specimens it appears that this species is extremely close to *Phenacaspis natalensis* Cockerell, of which authentic specimens are at hand from mango in South Africa and others from various hosts in Florida. It is also extremely close to specimens from *Magnolia* from China, identified as *Phenacaspis cockerelli* (Cooley). These may all be the same thing.

The above notes were written by Professor Ferris.

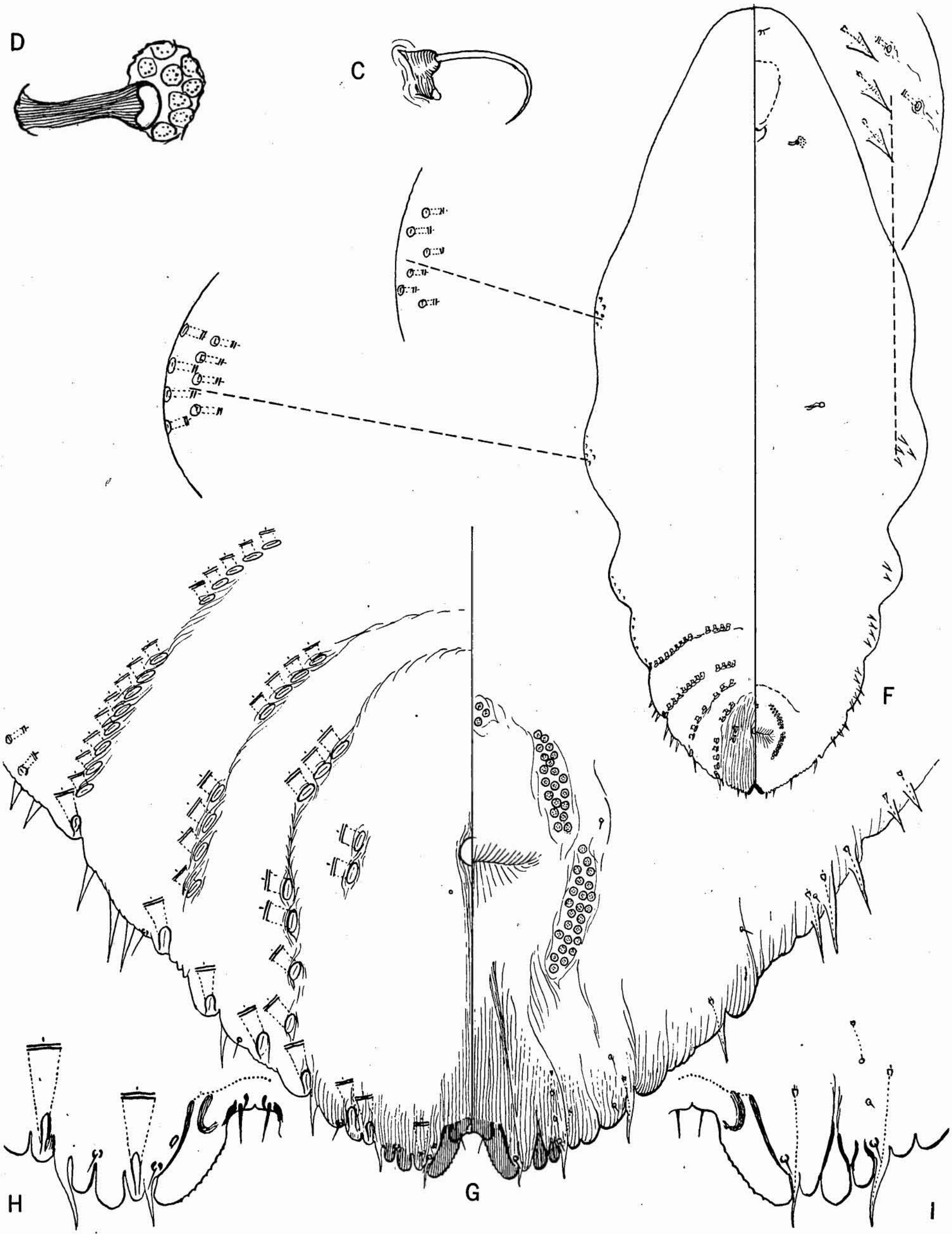


Figure 199—*Phenacaspis sandwicensis* (Fullaway), the oleander scale. (Drawn for this text by Ferris.)

Figure 200—*Phenacaspis sandwicensis* (Fullaway), the oleander scale, on a mango fruit; note the fine wax threads produced by the small individuals.

Phenacaspis sandwicensis (Fullaway) (figs. 199, 200).

Phenacaspis eugeniae variety *sandwicensis* Fullaway, 1932:103.

The oleander scale.

In earlier Hawaiian literature this was called *Phenacaspis* or *Howardia eugeniae* of Maskell by error of identification.

Oahu (type locality?—no type designation nor type locality other than "Hawaii" was given by Fullaway in his original description), Molokai.

Immigrant. Probably of Oriental origin. First recorded from Hawaii by Koebele (1898:110).

Hostplants: *Aleurites moluccana* ("kukui" or candlenut), bamboo, coconut, oleander, mango, *Moraea bicolor,* ylang-ylang (*Canangium odoratum*).

Parasites: *Arrhenophagus albipes* Girault (Hymenoptera: Encyrtidae); *Aspidiotiphagus citrinus* (Craw) (Hymenoptera: Aphelinidae).

Predator: *Lindorus lophanthae* (Blaisdell) (Coleoptera: Coccinellidae).

Female scale snow-white, 2–3 mm. long, pyriform, slightly convex; exuvia terminal, yellowish-brown; first larval stage lemon-yellow; body of female yellowish-brown, resembling a dried pear, 1.2 mm. long when mature. Male scale white, elongate, felted, tricarinate. Eggs 0.25 mm. long, lemon-yellow. When the young settle down they produce conspicuous coils of glistening wax threads (see the illustration).

Genus **PINNASPIS** Cockerell, 1892

Hemichionaspis Cockerell, 1897.
Jaapia Lindinger, 1914.
Lepidaspidis MacGillivray, 1921:275.
Ferris, 1937:SI–96.

KEY TO THE SPECIES OF PINNASPIS RECORDED FROM HAWAII

(From Ferris, with additions.)

1. Median lobes evidently fused so that there appears to be only a large, single, median, crenate lobe; length on slide about 1.5 mm.; female scale dark brown with pale yellow exuvia, length 2–3 mm. .... **uniloba** (Kuwana).
   Without such a combination of characters 2

2(1). Median lobes large and conspicuous, considerably exceeding second lobes which are usually much reduced; dorsum of pygidium normally with a pair of well-developed, crescent-shaped scleroses anterior to anus; scale white .... **strachani** (Cooley).
   Median lobes small or very small, equaled or even exceeded in length by adjacent gland prominence and second lobes, the latter well developed; dorsal scleroses anterior to pygidium very weakly developed or lacking; scale brown or translucent 2

3(2). Dorsal submarginal macroducts reduced in number, commonly lacking on fifth segment and with but one or two on fourth and third segments; metathorax in fully expanded specimens not strongly lobed laterally; scale of female pale and translucent, apparently parthenogenetic (no male scales) .... **buxi** (Bouché).
   Dorsal submarginal macroducts more numerous, usually at least two on segment 5 and three or four on segments 4 and 3; metathorax in fully expanded specimens quite strongly and acutely lobed laterally; scale of female brown, scales of males usually abundant, white and carinate .... **aspidistrae** (Signoret).

Pinnaspis aspidistrae (Signoret) (fig. 201).

Chionaspis aspidistrae Signoret, 1869:443, pl. 6, fig. 11.

Hemichionaspis aspidistrae (Signoret), of authors.

Ferris, 1937:SI–97. Ferris and Rao, 1947:30.

The fern scale.

Oahu.

Immigrant. Cosmopolitan. First listed from the Hawaiian Islands by Kotinsky (1910:128).

Hostplants: ferns, orchids.

Female scale thick, brown, length about 1 mm., elongate, oyster-like; exuvia terminal; male scale white, tricarinate. The presence of males will enable one to distinguish this species in the field from the similar *P. buxi.*

Doane reported this species to be a pest of coconut in Tahiti.

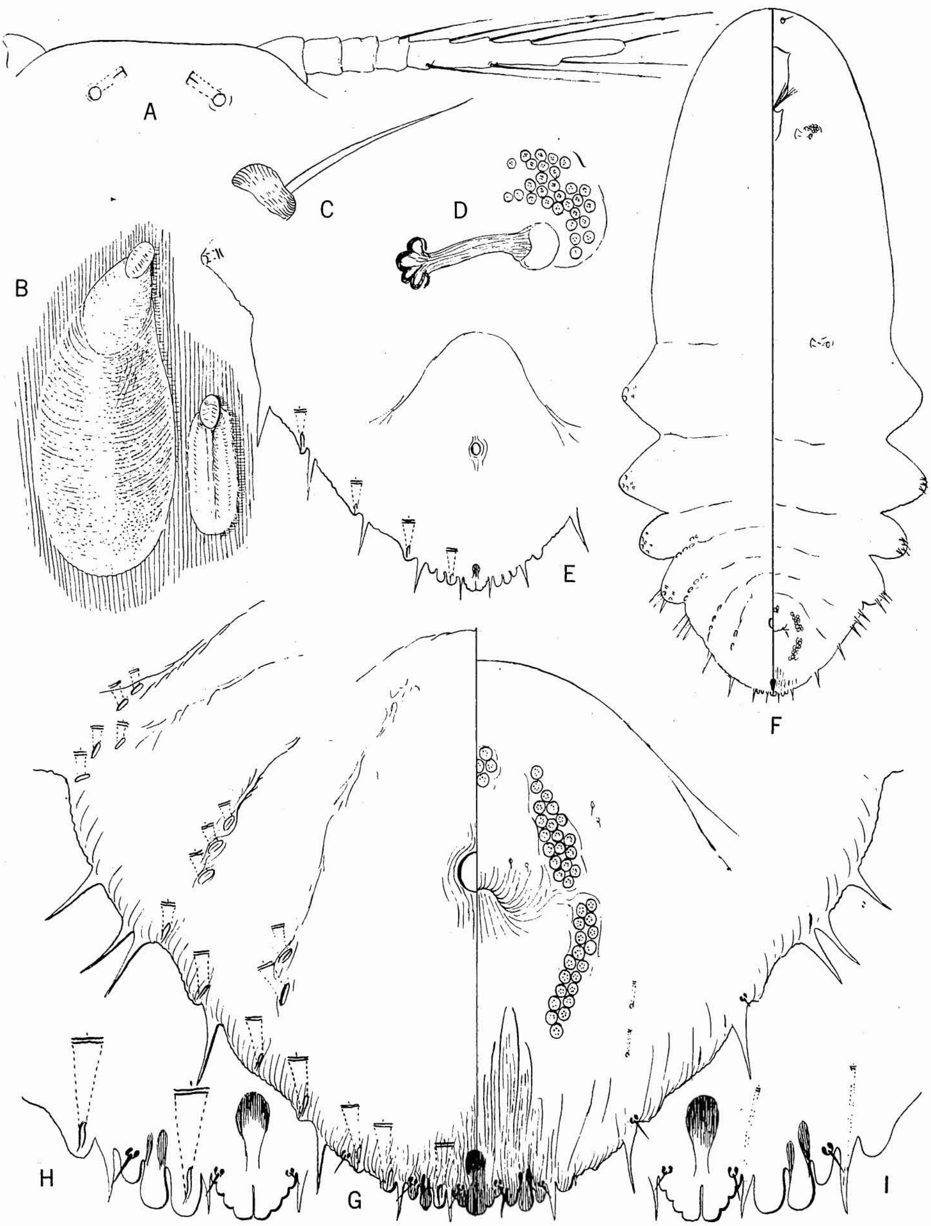


Figure 201—*Pinnaspis aspidistrae* (Signoret), the fern scale.

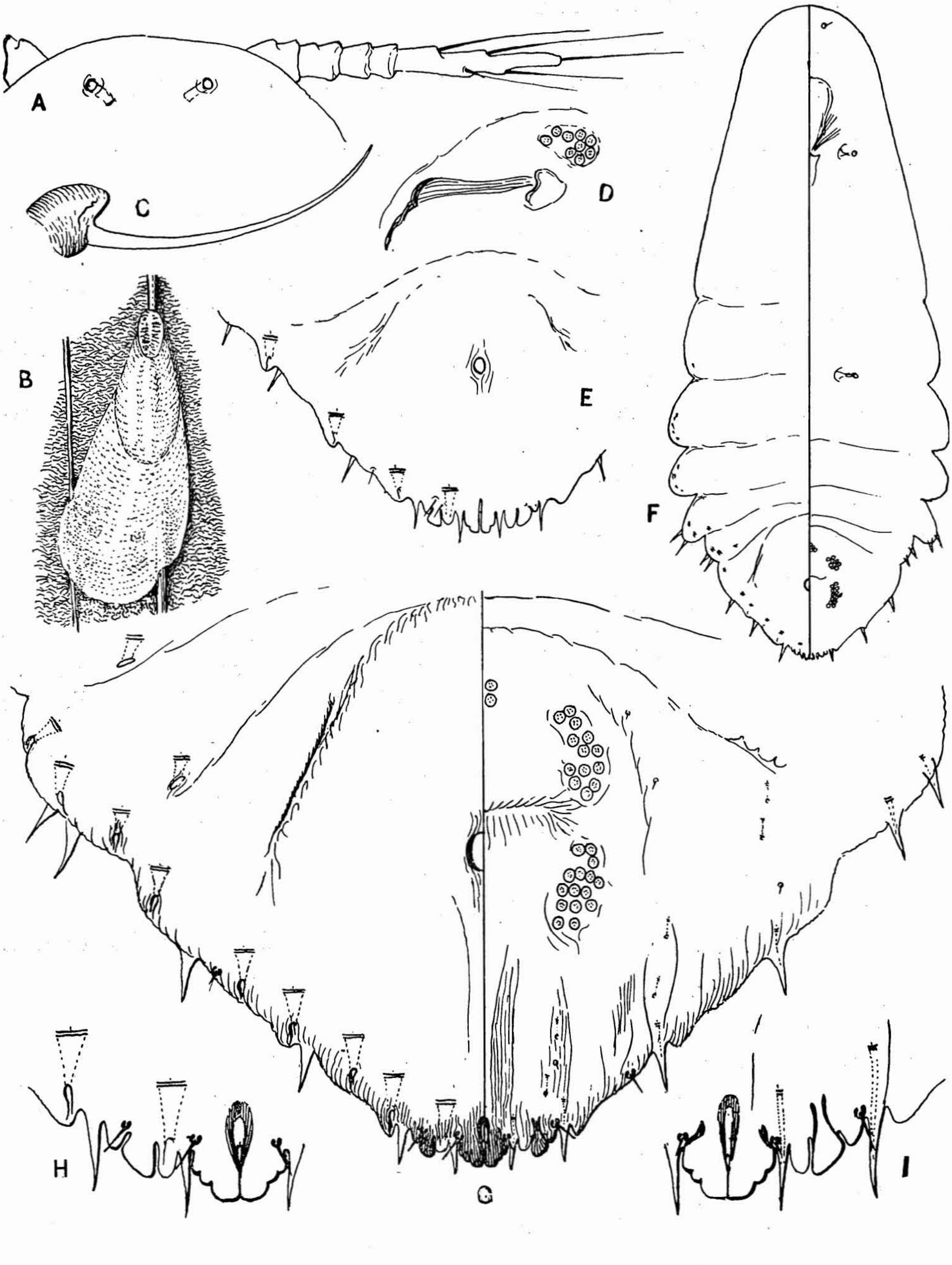


Figure 202—*Pinnaspis buxi* (Bouché), the coconut scale.

Pinnaspis buxi (Bouché) (fig. 202).

Aspidiotus Buxi Bouché, 1851:111.

Mytilaspis? pandanni Comstock, 1881:324, pl. 20, figs. 1, 2.

Ferris, 1937:SI–98. Ferris and Rao, 1947:32. Genotype of *Pinnaspis.*

The coconut scale.

Kauai, Oahu, Molokai.

Immigrant. A widespread species; described from *Pandanus* (misspelled *"Pandannis"*) by Comstock from the Harvard Botanic Garden. The above name was first used in Hawaiian literature by Ehrhorn in 1917 (*Proc. Hawaiian Ent. Soc.* 3 (4):268), who noted that it had been confused prior to 1916 with *Fiorinia fioriniae.*

Hostplants: coconut, *Hibiscus* (native species), *Monstera deliciosa, Moraea bicolor,* orchids, *Pandanus,* persimmon, *Philodendron.*

Parasites: *Aspidiotiphagus citrinus* (Craw), *Aphytis diaspidis* (Howard) (Hymenoptera: Aphelinidae).

Predators: *Chilocorus circumdatus* (Schönherr), *Telsimia nitida* Chapin (misidentified as *Cryptogonus nigripennis* Weise in some of our literature), *Sticholotis punctatus* Crotch (Coleoptera: Coccinellidae).

Female scale thin, brown, translucent, about 1 mm. long; evidently parthenogenetic, no males known.

This species has occasionally been so abundant on *Pandanus* as to cause severe staining of the leaves, thus rendering them worthless for use in plaiting; heavy infestations of coconut palms have caused considerable damage in Hawaii. The ladybird *Telsimia nitida* has exercised good control here since its introduction by Swezey from Guam in 1936. The absence of males in colonies of this species affords a good way of distinguishing the species in the field from *P. aspidistrae,* with which it might be confused.

Pinnaspis strachani (Cooley) (figs. 203, 204).

Hemichionaspis minor strachani Cooley, Hatch Expt. Station, Massachusetts Agr. College, Special Bull., p. 54, pl. 9, fig. 6, 1899.

Pinnaspis temporaria Ferris, 1942:SIV–407.

Chionaspis minor Maskell, in part, of authors.

Hemichionaspis minor (Maskell), as a misidentification.

For detailed synonymy and discussion, see Ferris and Rao, 1947:39, figs. 19, 19*a.*

The hibiscus snow scale.

Oahu.

Immigrant. A widespread species; first recorded from the Hawaiian Islands by Kotinsky (1910:128).

Hostplants: *Antigonon leptopus, Asparagus,* avocado, coconut, *Cordyline terminalis,* ferns, *Geranium, Gossypium tomentosum, Hibiscus,* jasmine ("pikake"), poinciana, *Verschaffeltia, Waltheria, Wistaria,* yams.

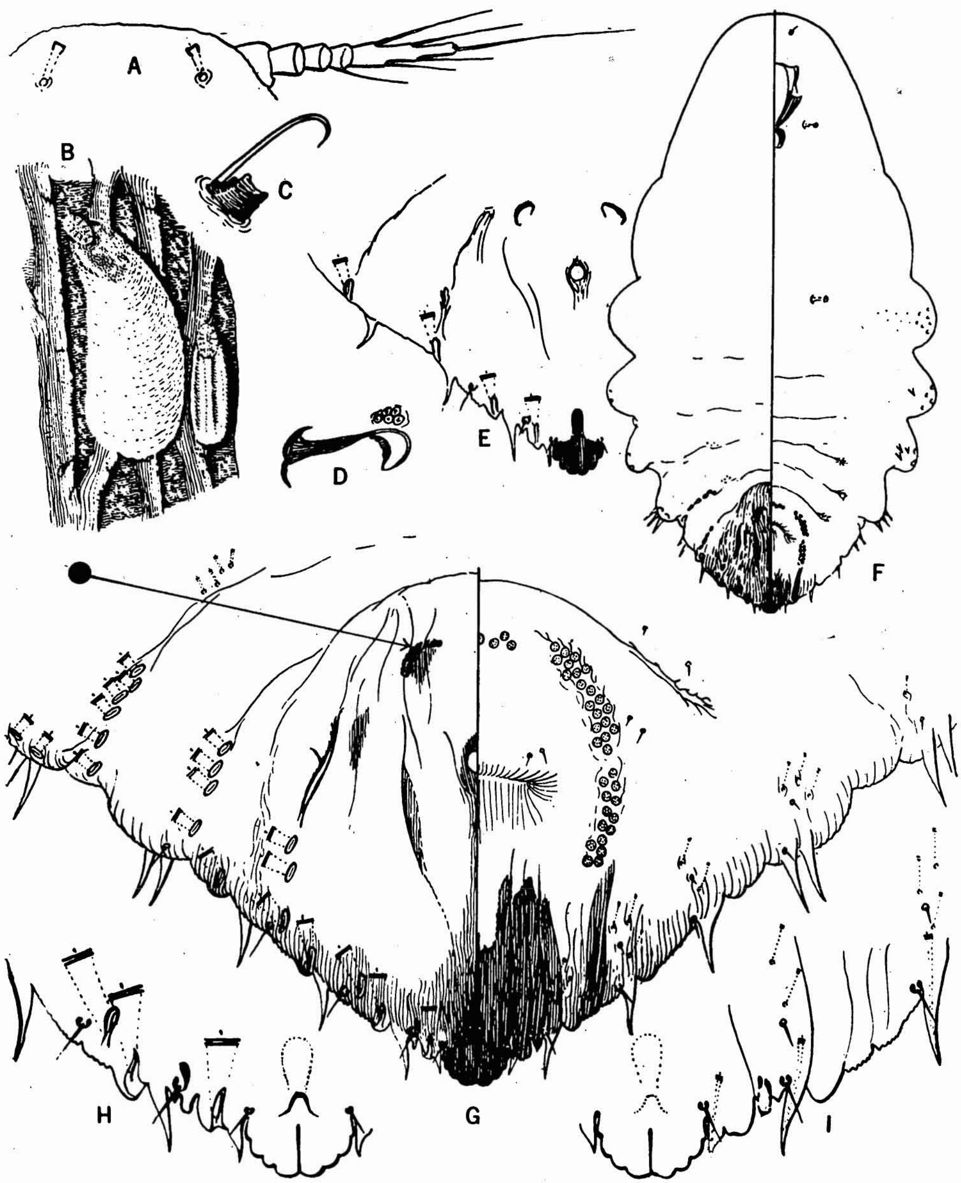


Figure 203—*Pinnaspis strachani* (Cooley), the hibiscus snow scale.

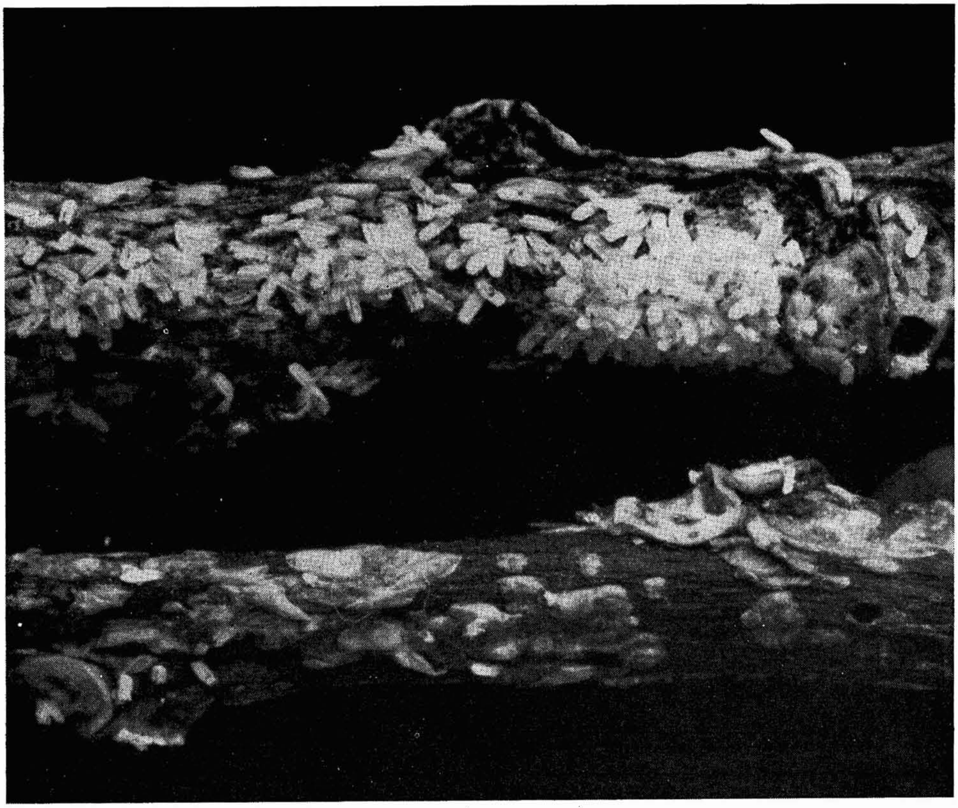


Figure 204—*Pinnaspis strachani* (Cooley), the hibiscus snow scale, on *Hibiscus*.

Parasites: *Aphytis diaspidis* (Howard), *Aphytis chrysomphali* (Mercet), *Aspidiotiphagus citrinus* (Craw) (Hymenoptera: Aphelinidae). The parasites sometimes kill 90 percent or more of the scales in a colony.

Female scale opaque white, elongate but fairly broad; male scale 1–2 mm. long, snow-white, tricarinate.

This scale frequently masses on its host, especially on the stems, which it may completely conceal. The fluted male scales are most conspicuous, and the less obvious females may be overlooked easily and may be mostly concealed by the males.

Pinnaspis uniloba (Kuwana) (fig. 205).

Mytilaspis (*Lepidosaphes*) *uniloba* Kuwana, 1909:156, pl. 9, figs. 42–45.

Lepidaspidis uniloba (Kuwana) MacGillivray, 1921:292.

Lepidosaphes uniloba (Kuwana) Fullaway, Proc. Hawaiian Ent. Soc. 7 (3):340, 1931.

Ferris and Rao, 1947.

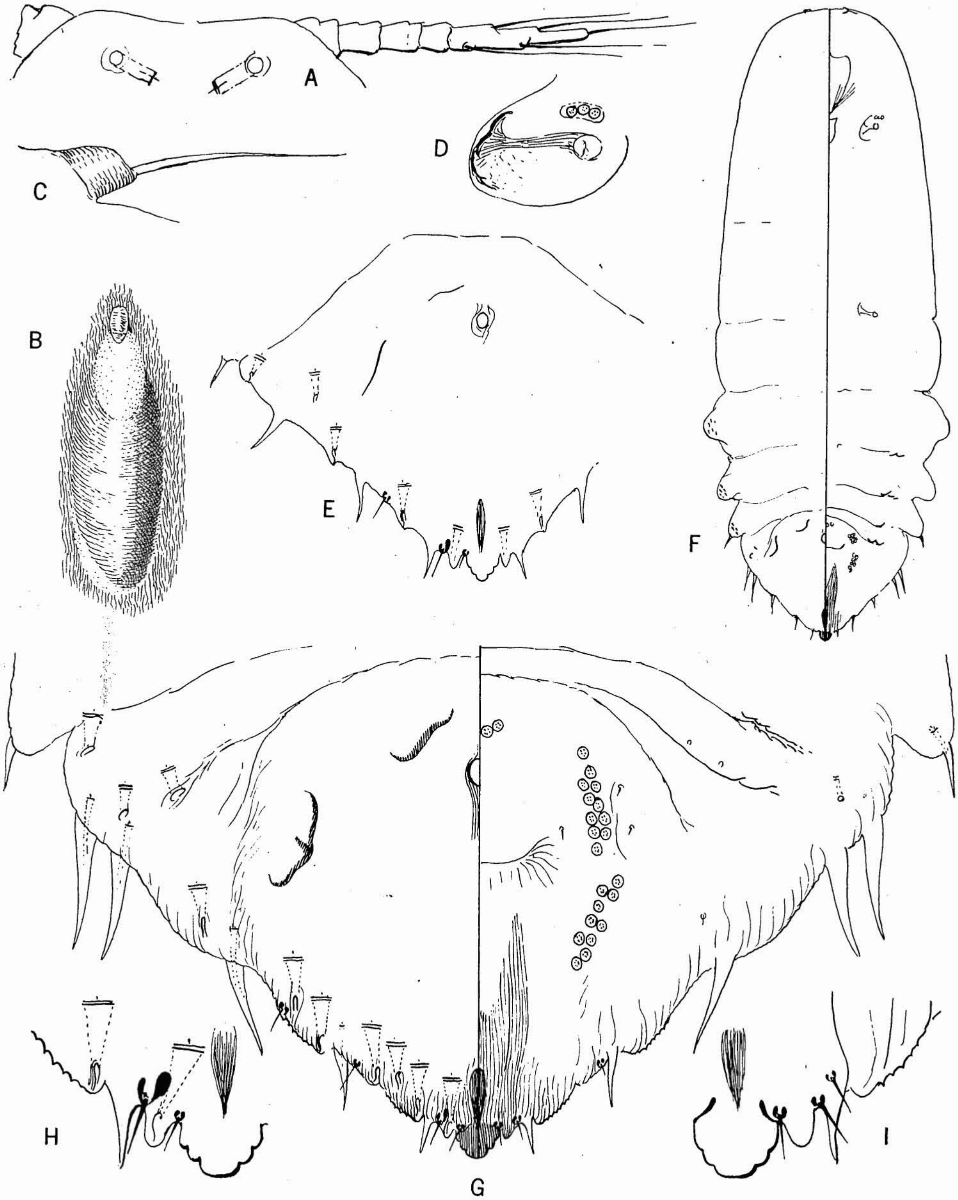


Figure 205—*Pinnaspis uniloba* (Kuwana). (Drawn for this text by Ferris.)

Oahu.

Immigrant. The first record of this species in Hawaii to come to my attention is that by Fullaway in 1931, although it was known for some years prior to that date.

Hostplant: *Alyxia olivaeformis* ("maile").

Female scale very long and narrow (2–3 mm.), hardly broadening caudad, dark brown, exuvia yellowish.

Genus **GENAPARLATORIA** MacGillivray, 1921:248

Ferris, 1937:SI–60. McKenzie, 1945:80.

Genaparlatoria pseudaspidiotus (Lindinger) (fig. 206).
Parlatoria pseudaspidiotus Lindinger, 1905:131.
Genaparlatoria pseudaspidiotus (Lindinger) MacGillivray, 1921:248, 255.
Ferris, 1937:SI–61. McKenzie, 1945:80, fig. 54.

Oahu.

Immigrant. An Oriental species. First listed from the Hawaiian Islands by Fullaway in 1938 (*Proc. Hawaiian Ent. Soc.* 10 (1):46).

Hostplants: orchids, including *Vanda.*

Female scale brownish, circular, with a waxy asymmetrical extension at one side, exuvia central, the second one large.

Genus **PARLATORIA** Targioni-Tozzetti, 1869

Ferris, 1937:SI–84. Morrison, 1939:1–34. McKenzie, 1945:47–121.

Key to the Species Recorded from Hawaii

(Revised from Ferris.)

1. With a peculiar, ear-like lobe on each side margin of head region about opposite anterior spiracles; without sclerotized gland tubercles on prosoma; female scale composed largely of unusually large, black second exuvium, behind and beneath which protrudes a shorter white scale, and first exuvium is at extreme anterior end; scale on host leaf appearing as a decidedly black species.. **zizyphus** (Lucas).
Not so 2

2(1). Fourth pygidial lobe suppressed or represented by an unsclerotized projection which, except for size, resembles adjacent plates; (female scale thin, nearly transparent; first exuvium overlapping anterior end; second exuvium yellow or brownish).................... **proteus** (Curtis).

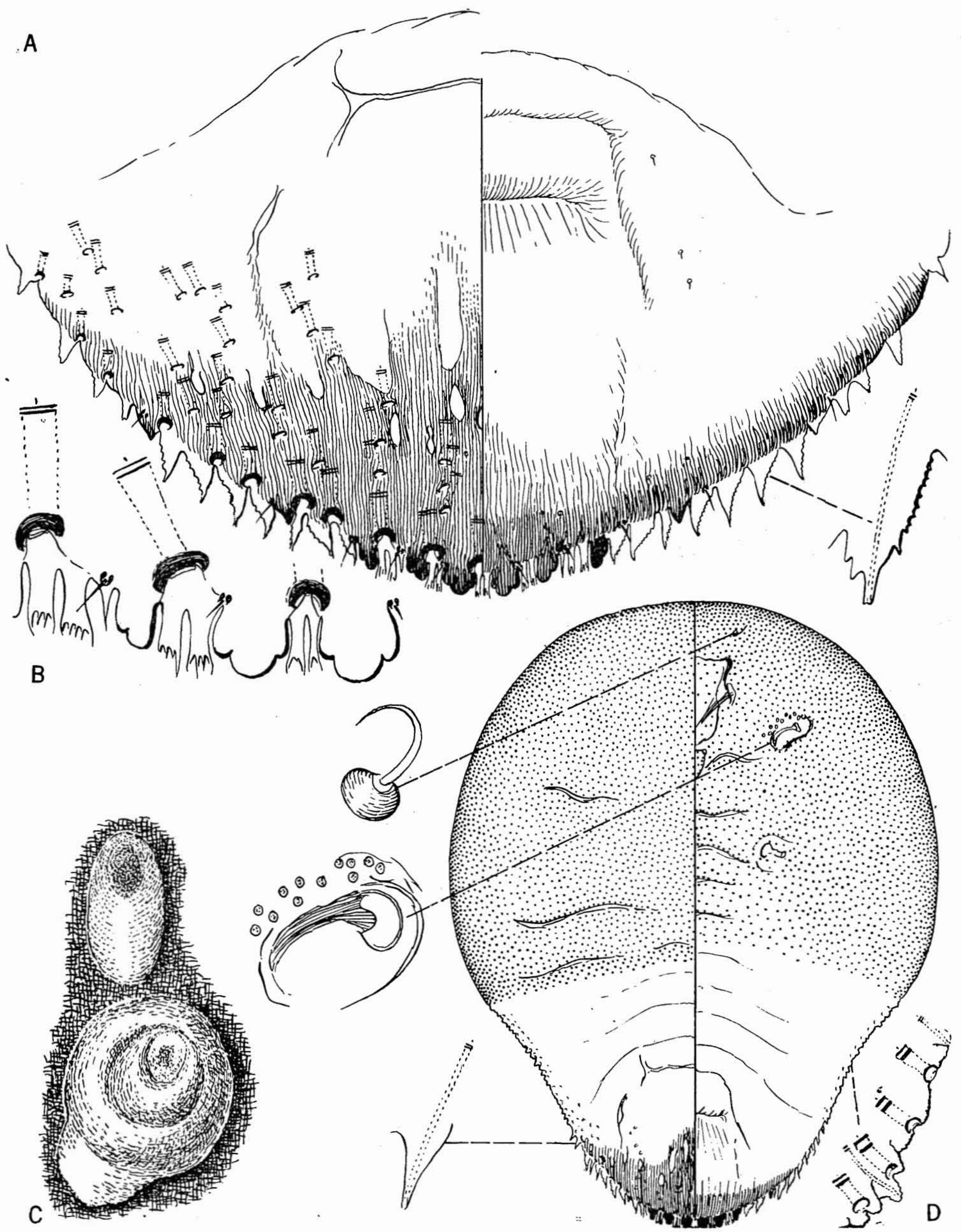


Figure 206—*Genaparlatoria pseudaspidiotus* (Lindinger). (Drawn for this text by Ferris.)

Fourth pygidial lobe developed as a small, distinctly sclerotized, somewhat dentate tooth-like point.......... 3

3(2). Head region with a distinct, sclerotized, acute tubercle (ocular spur) on each side, nearly opposite each anterior spiracle, and usually well developed; female scale yellow or greenish, flat; first exuvium yellow, overlapping anterior end; second exuvium with irregular darker median mottling........................**crotonis** (Douglas).

Head region without ocular spurs; female scale rather thick, gray or brown, first exuvium set in from anterior margin ....**pergandei** Comstock.

Parlatoria crotonis (Douglas) (figs. 207, 208, 209).

Parlatoria proteus variety *crotonis* Douglas, 1887:242.

Ferris, 1942:SIV–401. Morrison, 1939:12, figs. McKenzie, 1945:61, figs.

Oahu.

Immigrant. A widespread species described from England. Evidently first noted in Hawaiian literature by Fullaway in 1932 (p. 93).

Hostplant: croton (*Codiaeum variegatum*).

The female scale is elongate-oval, flat, yellow or tinged with green, exuvia yellow, darker than scale, first exuvium overlapping anterior end, second with darker markings; male scale yellowish.

This species has been listed as *Parlatoria proteus crotonis,* but it is specifically distinct from *proteus.*

Parlatoria pergandei Comstock (figs. 210, 211, 212).

Parlatoria pergandei Comstock, 1881:327, pl. 11, fig. 4; pl. 20, fig. 5.

Ferris, 1937:SI–88. Morrison, 1939:18, figs. McKenzie, 1945:70, figs.

Pergande's scale, the chaff scale.

Oahu.

Immigrant. The first reference to this widespread species in Hawaiian literature appears to be that by Koebele (1898:109), but it is not well known here.

Hostplant: *Citrus.*

"Occurring on bark, leaves, and fruit of the host. Scale rather thick, gray, or brown, the second exuvium not unusually large." (Ferris, 1937.)

Comstock coined the common name "Pergande's scale" when he described the species as new.

Parlatoria proteus (Curtis) (figs. 213, 214, 215).

Aspidiotus proteus Curtis, 1843:676, figs. 1–8.

Ferris, 1937:SI–89. Morrison, 1939:22, figs. McKenzie, 1945:72, figs.

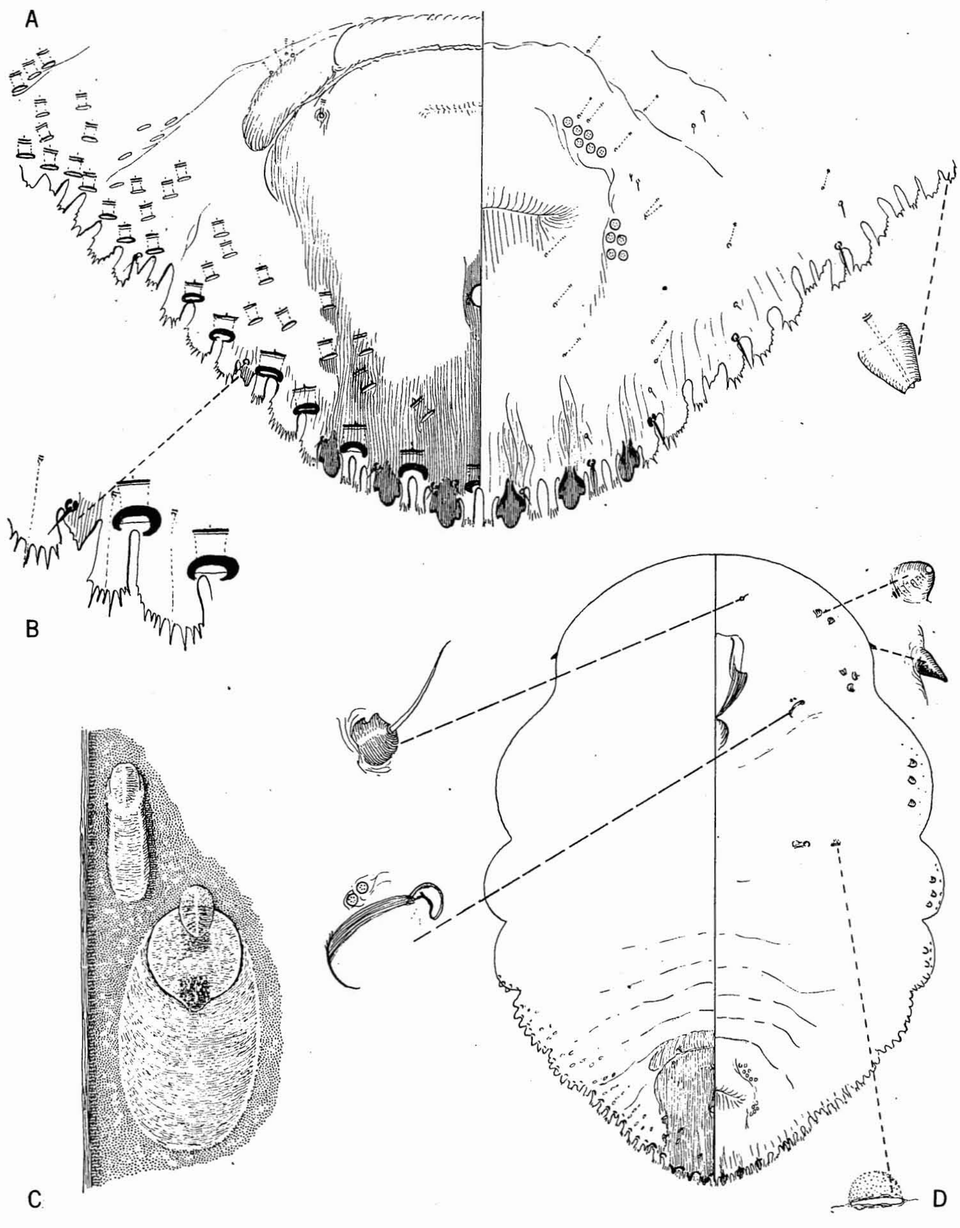


Figure 207—*Parlatoria crotonis* (Douglas).

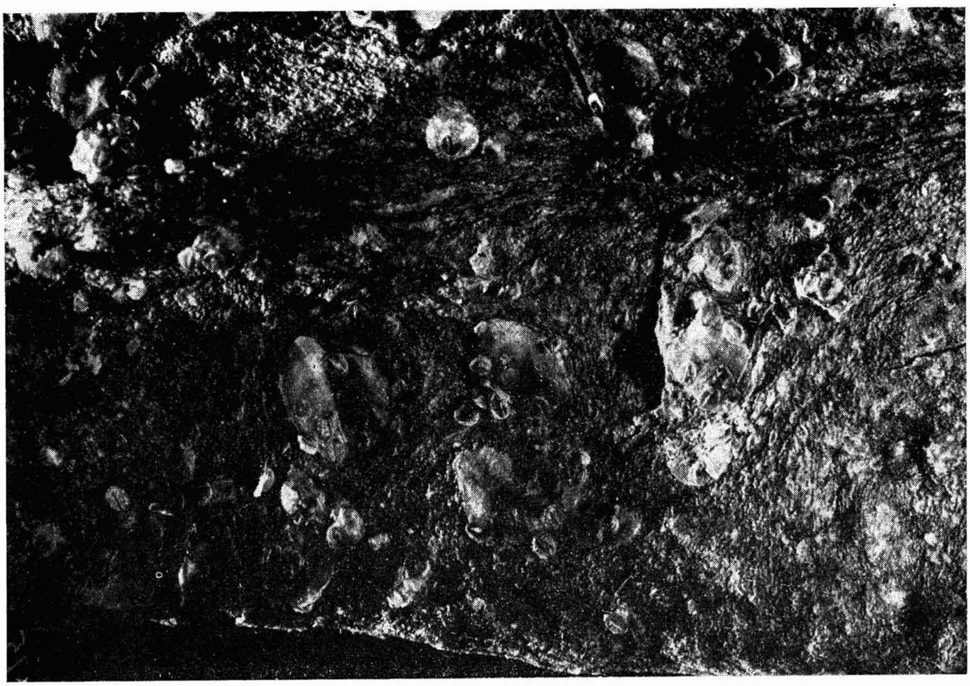


Figure 208—*Parlatoria crotonis* (Douglas). (Photograph supplied by Harold Morrison.)

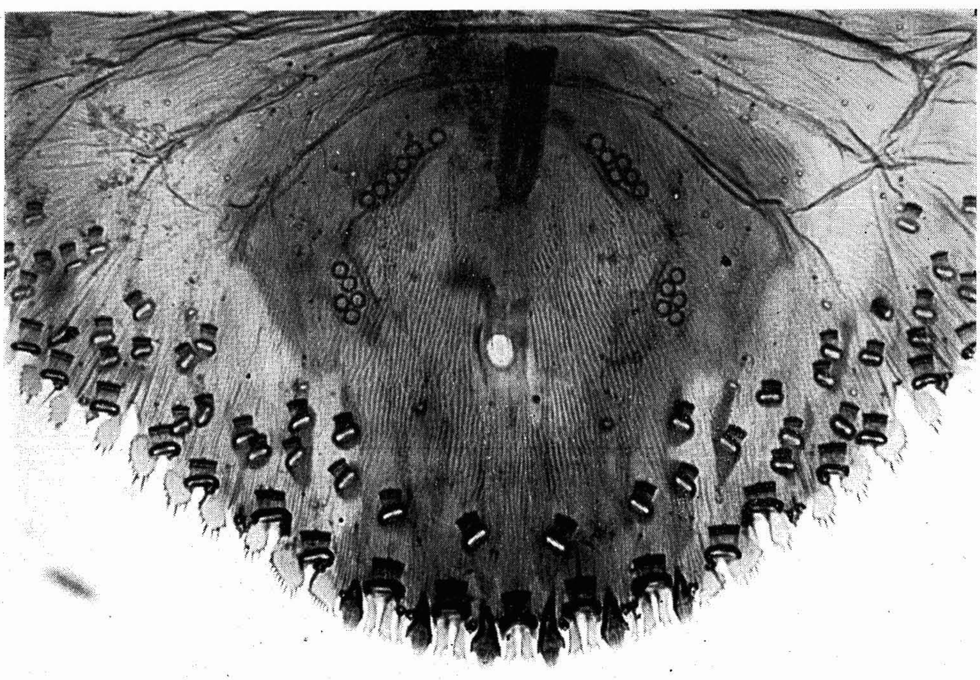


Figure 209—*Parlatoria crotonis* (Douglas), photograph of pygidium. (Courtesy of Harold Morrison.)

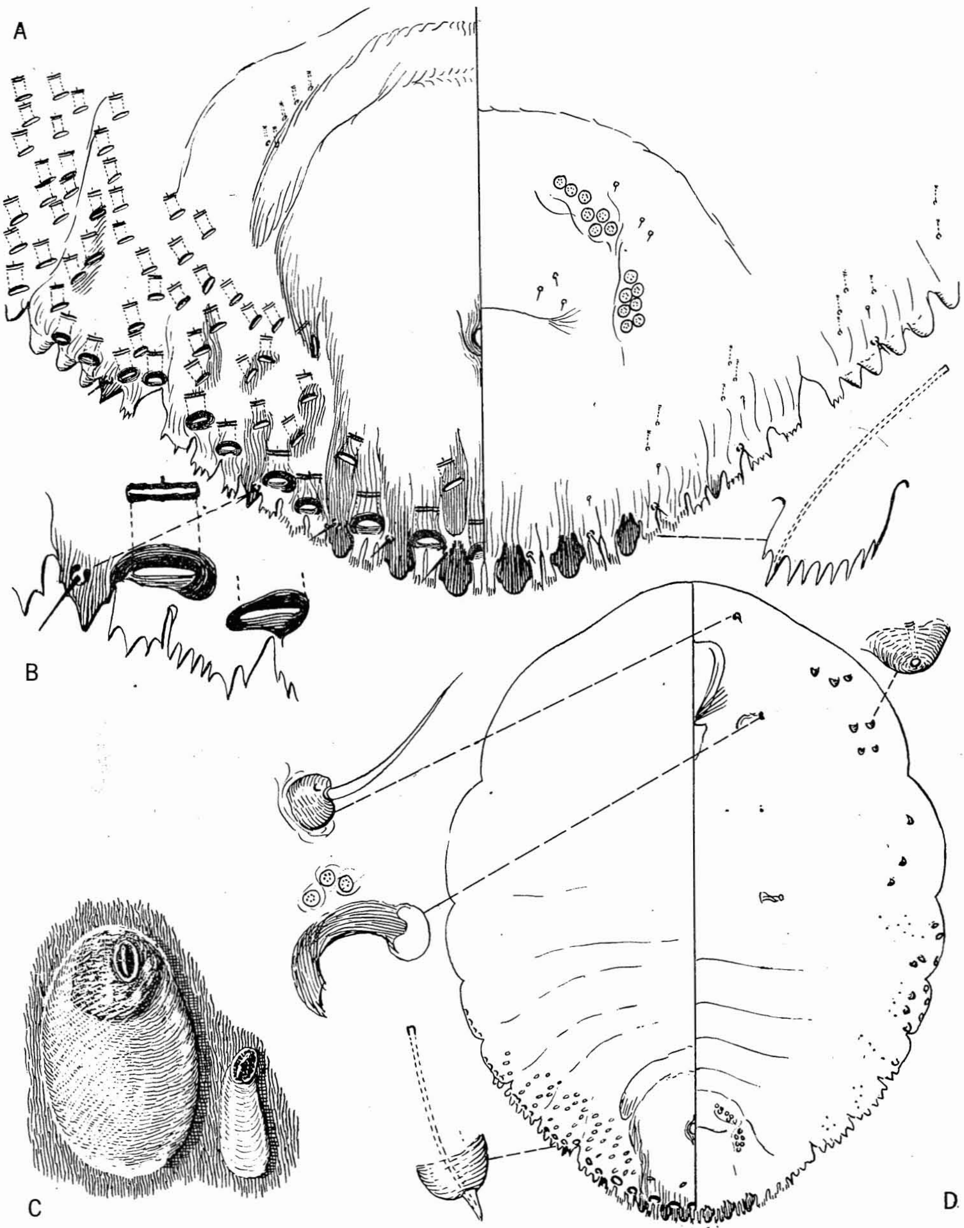


Figure 210—*Parlatoria pergandei* Comstock, Pergande's scale.

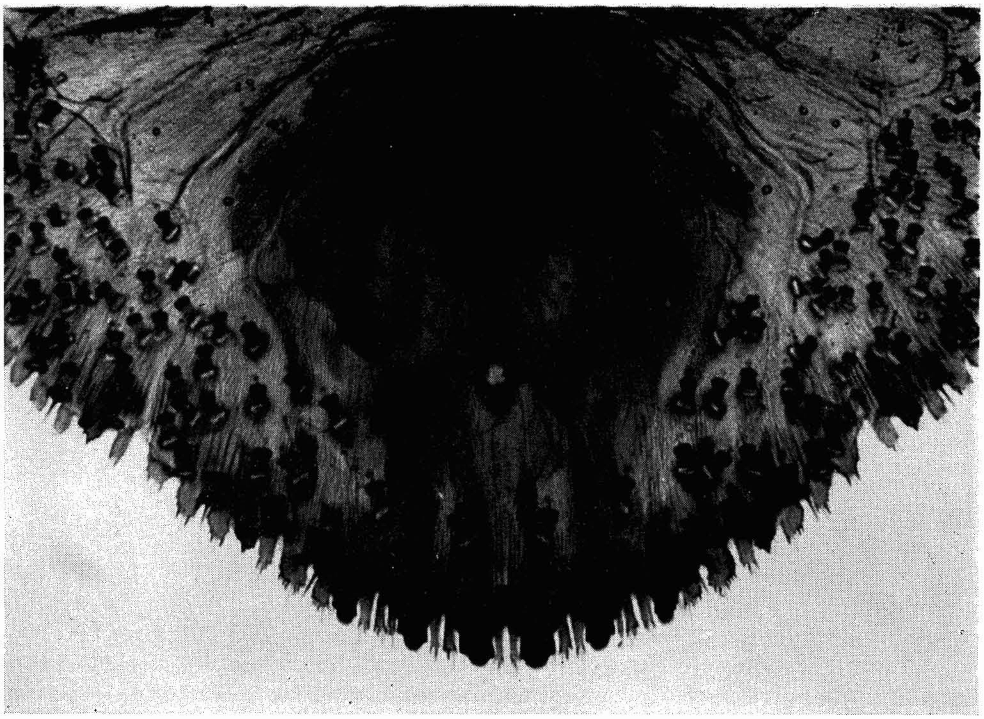


Figure 211—*Parlatoria pergandei* Comstock, pygidium. (Photograph kindly supplied by Harold Morrison.)

Figure 212—*Parlatoria pergandei* Comstock. (Photograph courtesy of Harold Morrison.)

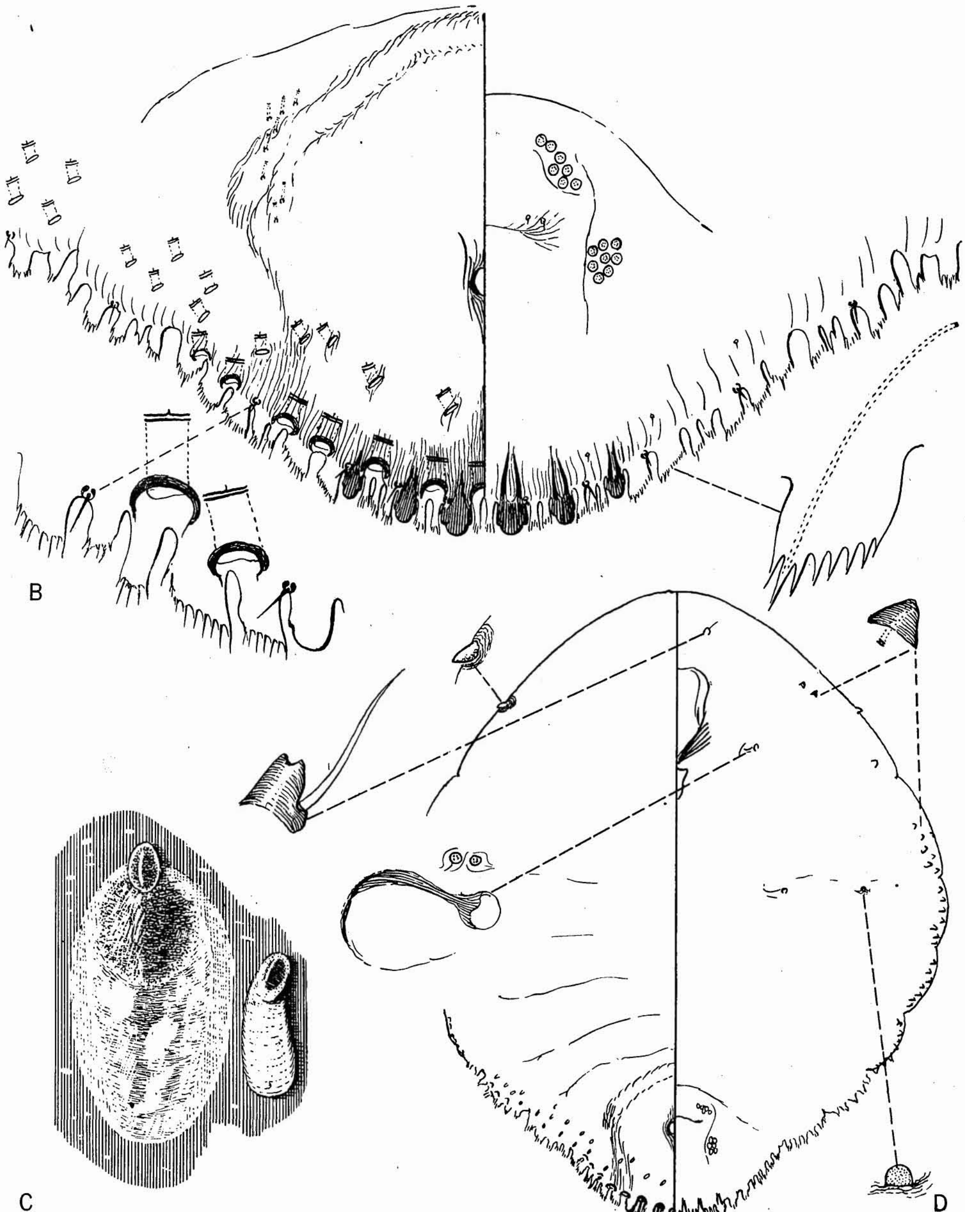


Figure 213—*Parlatoria proteus* (Curtis).

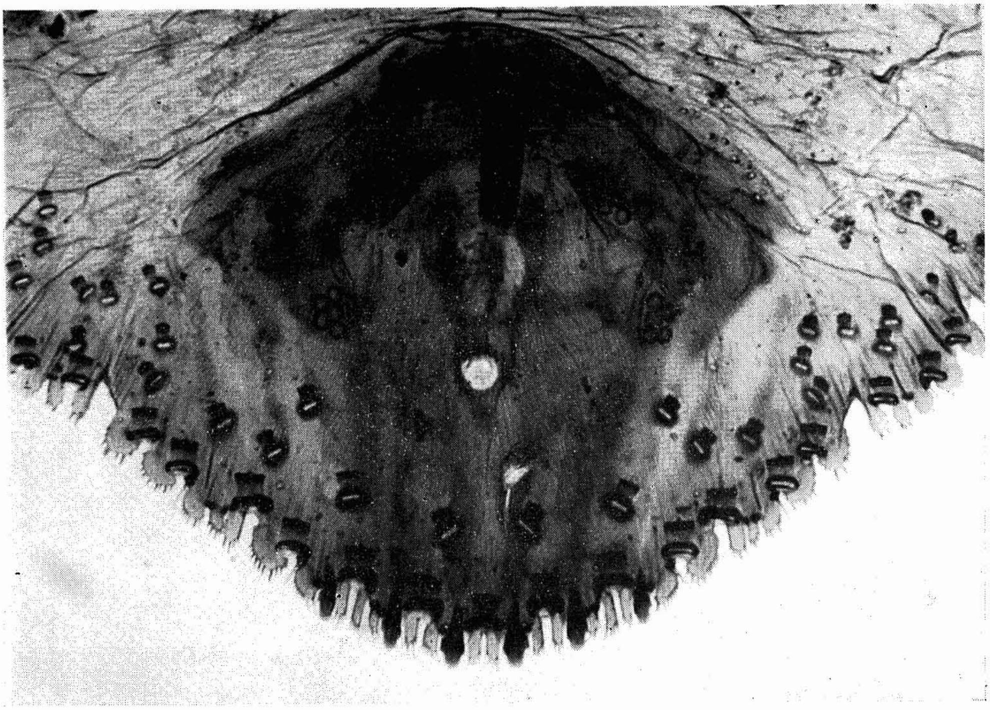


Figure 214—*Parlatoria proteus* (Curtis), photograph of pygidium. (Courtesy of Harold Morrison.)

Figure 215—*Parlatoria proteus* (Curtis). (Photograph supplied by Harold Morrison.)

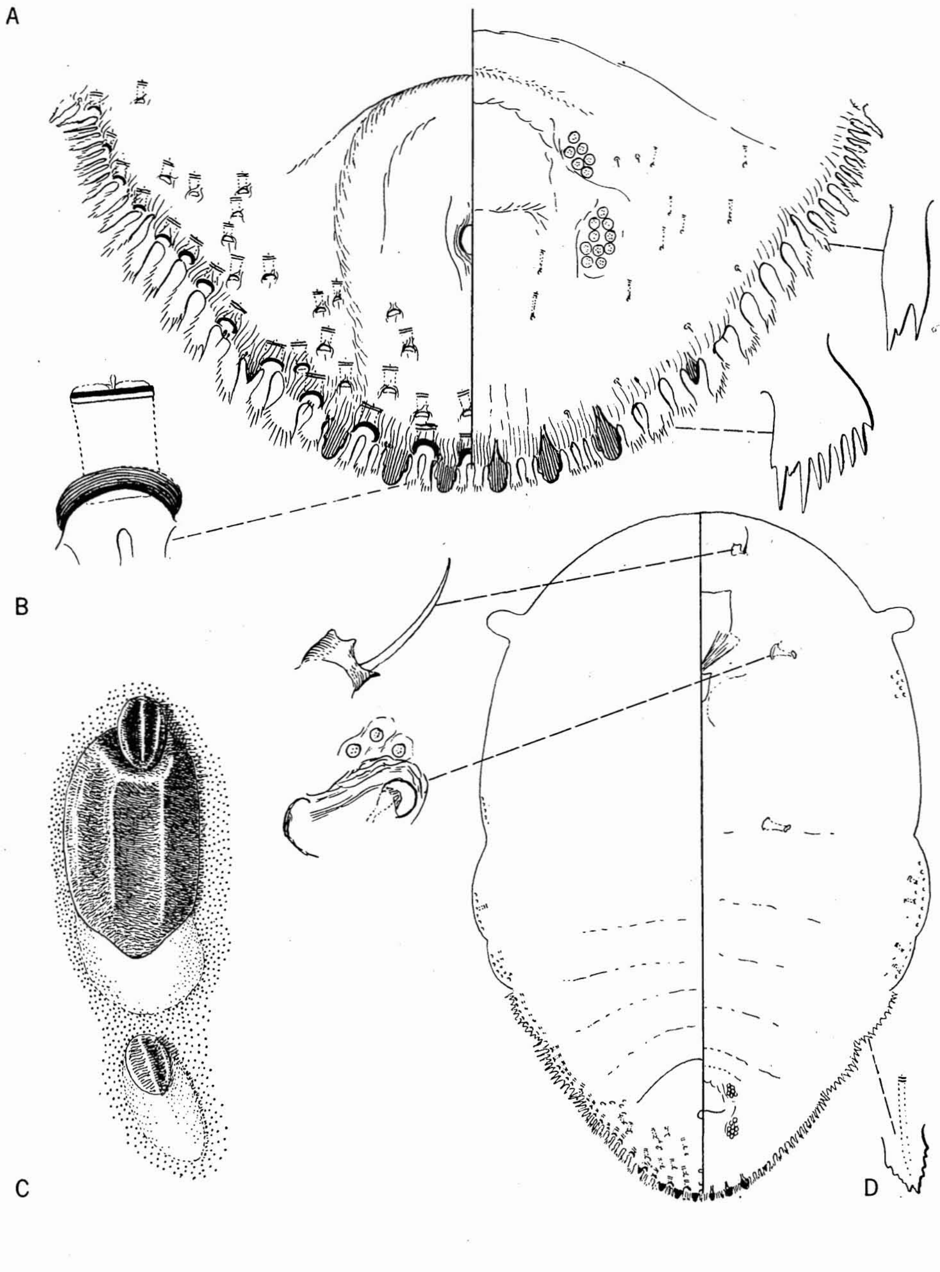


Figure 216—*Parlatoria zizyphus* (Lucas), the Mediterranean scale.

Oahu.

Immigrant. A cosmopolitan species. It was first found in Hawai by Koebele. It was listed by Kotinsky in 1910 (p. 130) as *P. mytilaspiformis* Green, which name has also been used in more recent Hawaiian literature.

Hostplants: *Cycas,* mango, *Monstera,* orchids (*Cypripedium, Dendrobium, Philodendron, Vanda*), "palm." (The local records listing croton as a host are here considered as applicable to *Parlatoria crotonis.*)

"Occurring on bark, leaves, or fruit of the host. Scale of the female very thin and delicate, almost transparent, the second exuvium quite large, yellow or brown; scale of male elongate, white, exuvium yellow or brown." (Ferris, 1937.)

Parlatoria zizyphus (Lucas) (figs. 216, 217, 218).

Coccus zizyphus Lucas, Bull. Soc. Ent. France (III) 1:xxviii, 1853 (I have not examined this reference).

Ferris, 1937: SI–90. Morrison, 1939:27, figs. McKenzie, 1945:76, figs.

The Mediterranean scale.

Oahu.

Immigrant. Cosmopolitan. First listed from Hawaii by Koebele (1898:109).

Hostplant: *Citrus.*

Parasites: *Aspidiotiphagus agilior* Berlese, *Aspidiotiphagus citrinus* (Craw) (Hymenoptera: Aphelinidae).

Predator: *Orcus chalybeus* (Boisduval) (Coleoptera: Coccinellidae).

This is a common *Citrus*-infesting species and is the most easily recognized of our species of *Parlatoria.* It may mass on the leaves and fruit of the host where it appears as a conspicuously black scale. However, under magnification, it is revealed that the female scale (which is about 1.75 mm. in length when grown uncrowded) consists largely of the unusually large, black, second exuvium which makes up about two-thirds of its length and is carinate longitudinally, and behind and narrowly around this extends a white, waxy scale. The first exuvium is black, carinate and overlaps the anterior margin. The male scale is white with a black exuvium. Once known, this scale is always easy to recognize. The ear-like lobes seen in slide-mounted specimens are peculiar and diagnostic.

Carter (1935:284) reports excellent control by using a 3-percent Diesel oil–bentonite emulsion spray.

Genus **ISCHNASPIS** Douglas, 1887

Ferris, 1937:SI–66.

Ischnaspis longirostris (Signoret) (figs. 219, 220).

Mytilaspis longirostris Signoret, 1882:xxxv.

Ferris, 1937:SI–67.

The black thread scale.

Oahu, Molokai.

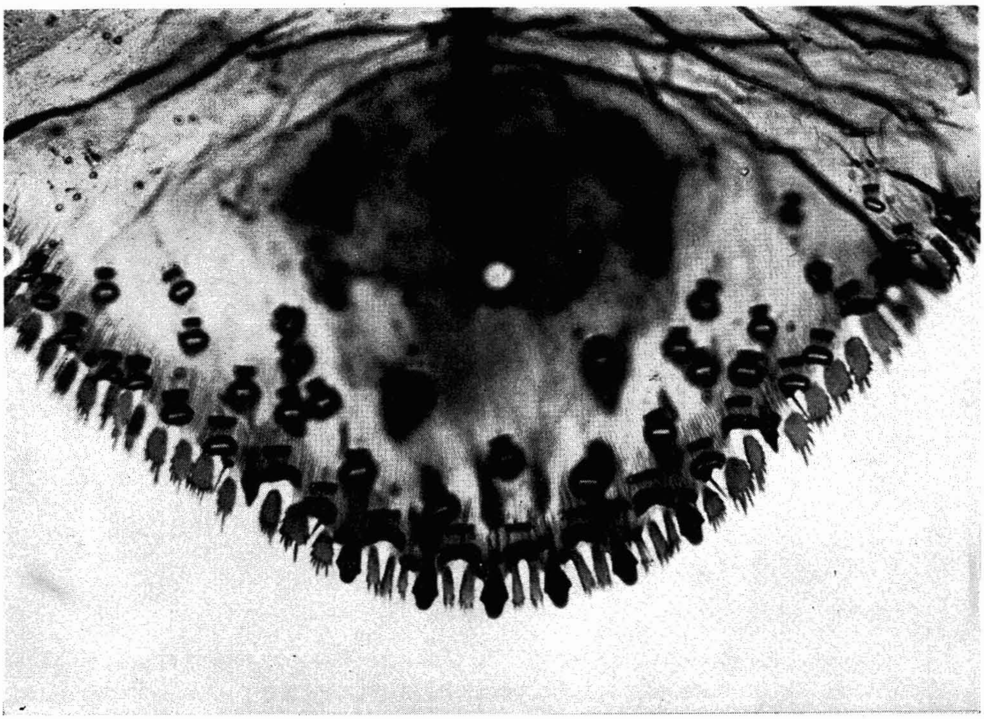


Figure 217—*Parlatoria zizyphus* (Lucas), the Mediterranean scale; photograph of pygidium. (Courtesy Harold Morrison.)

Figure 218—*Parlatoria zizyphus* (Lucas). (Courtesy of Harold Morrison.)

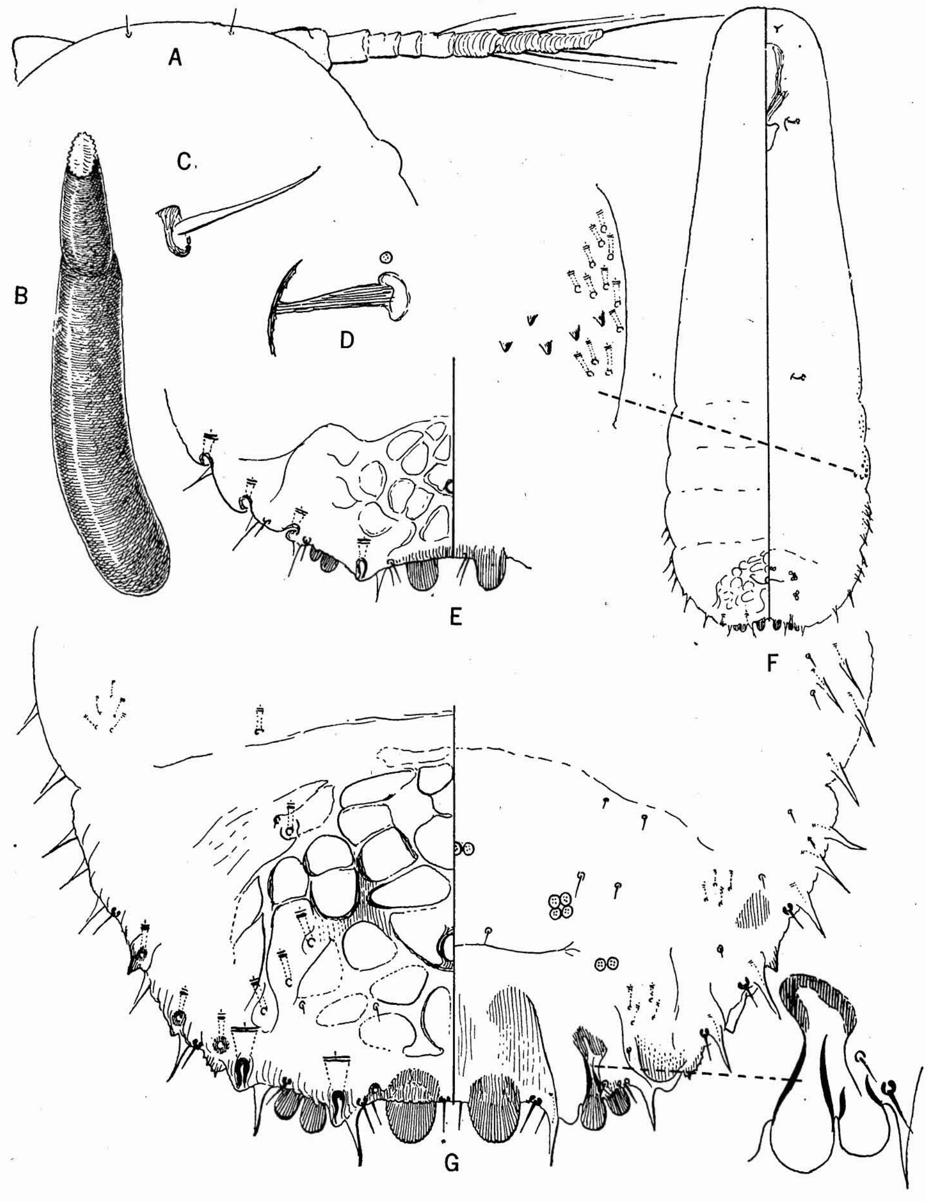


Figure 219—*Ischnaspis longirostris* (Signoret), the black thread scale.

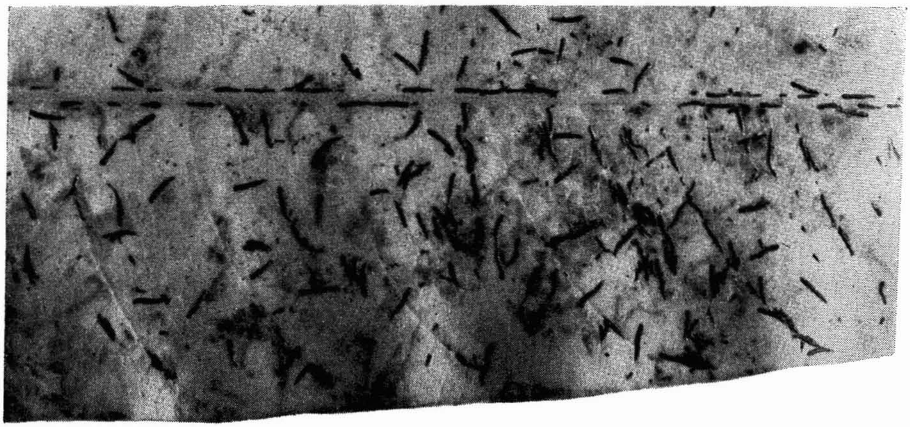


Figure 220—*Ischnaspis longirostris* (Signoret), the black thread scale, on a mango leaf.

Immigrant. Almost cosmopolitan. The first reference to this species in my file of Hawaiian literature appears to be that by Fullaway (1932:100), but it has been known here for a long while.

Hostplants: coconut, *Ficus bengalensis,* mango, *Moraea bicolor,* palms, *Pandanus,* star jasmine.

The female scale is very long and slender (up to 3 mm. in length), black, shiny, the first exuvium extending beyond the anterior end. Slide-mounted specimens reveal the strongly reticulate pattern of the pygidial dorsum and the large, well-separated median lobes.

This species frequently becomes extraordinarily abundant on leaves. Swezey (*Proc. Hawaiian Ent. Soc.* 12 (2) :221, 1945) found 240 scales per square inch on leaves of *Ficus bengalensis,* with an estimated total of 4,100 scales to a single leaf.

Genus **ANDASPIS** MacGillivray, 1921:275

Ferris, 1937:SI–3.

Andaspis hawaiiensis (Maskell) (fig. 221).

Mytilaspis flava variety *hawaiiensis* Maskell, 1895:47.

Oahu, Kauai (type locality).

Immigrant. Although originally described from Koebele's Hawaiian material, this scale is now known to be widespread around the world.

Hostplants: "bark of trees," orange, "shade trees."

This species seldom has been collected in Hawaii. "Scale of the female elongate, white, but usually obscured under the epidermis of the host; exuvia apical; scale of the male similar to that of the female in form and texture." (Ferris, 1937:SI–4.)

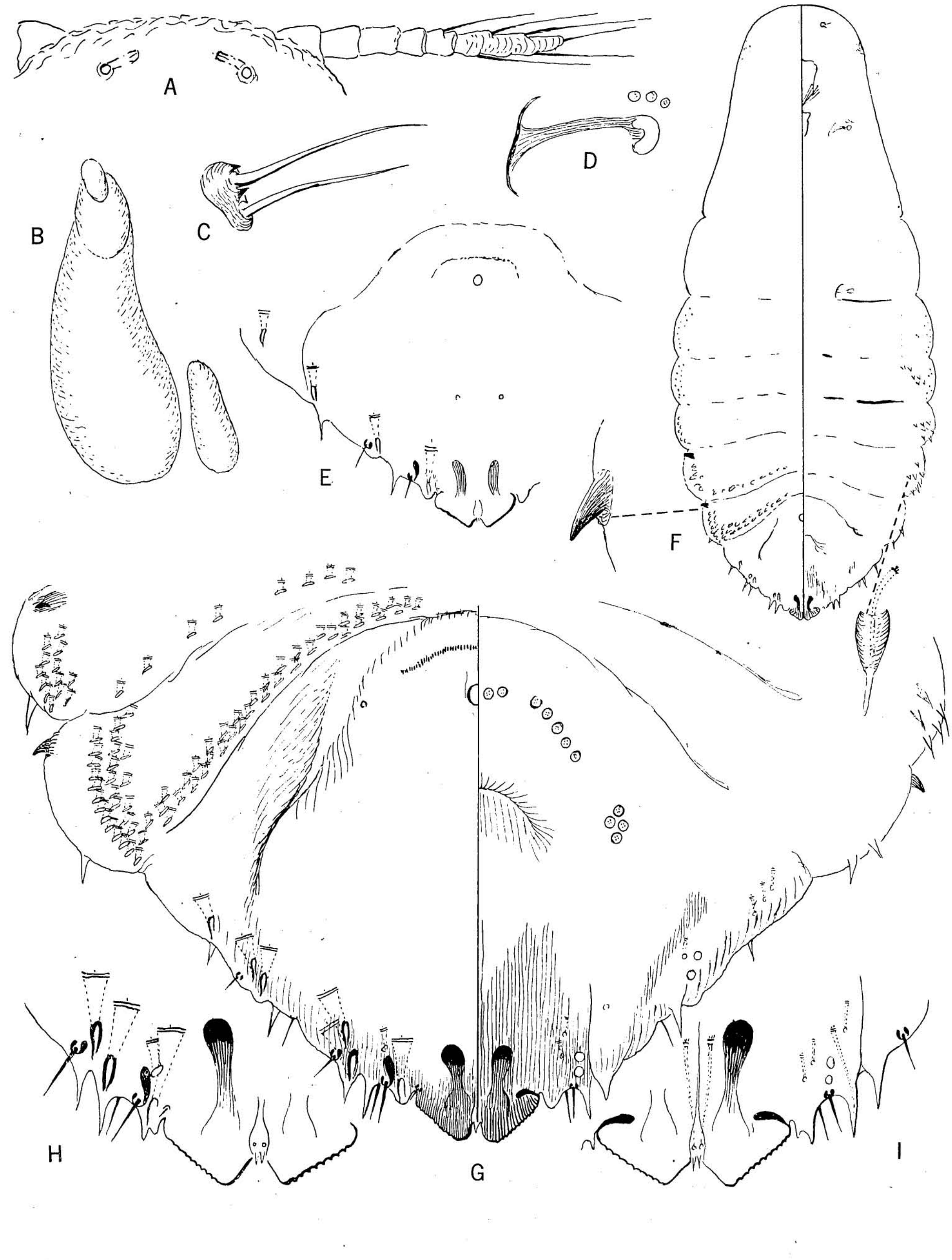


Figure 221—*Andaspis hawaiiensis* (Maskell).

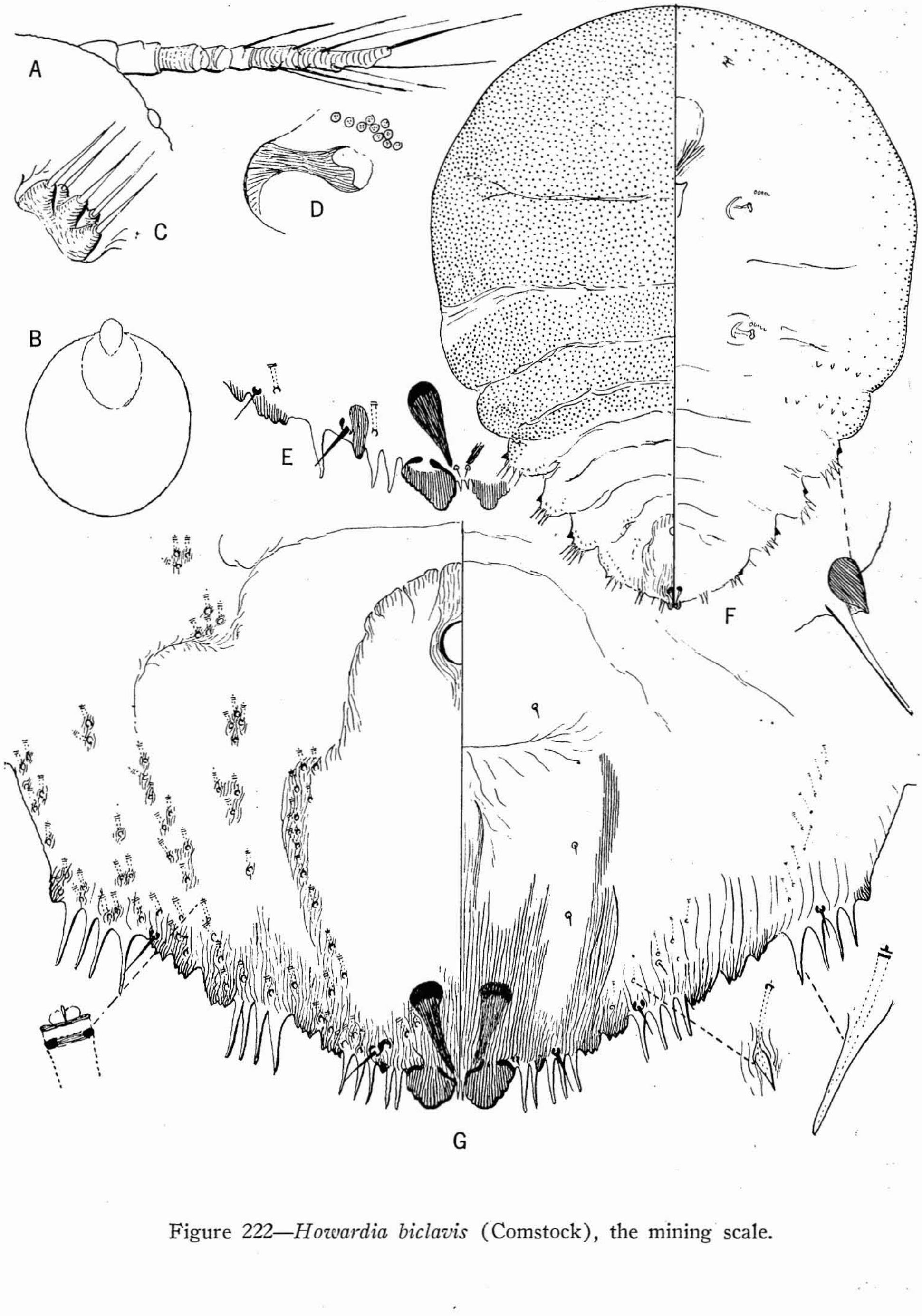


Figure 222—*Howardia biclavis* (Comstock), the mining scale.

Genus **HOWARDIA** Berlese and Leonardi, 1896

Ferris, 1937:SI–64.

Howardia biclavis (Comstock) (fig. 222).

Chionaspis ? biclavis Comstock, 1883:98, fig. 12; pl. 2, fig. 11.
Chionaspis biclavis variety *detecta* Maskell, 1895:49.
Ferris, 1937:SI–65. Genotype of *Howardia*.

The mining scale.

Oahu, Hawaii.

Immigrant. Tropicopolitan, and in hothouses in the temperate zones. First listed by Maskell in 1895 as a new form, as above, from Kona, Hawaii.

Hostplants: *Cassia, Ficus, Hibiscus, Nephelium,* papaya, *Plumeria, Sterculia foetida.*

Parasites: *Pseudopteroptrix imitatrix* Fullaway, *Aphytis diaspidis* (Howard) (Hymenoptera: Aphelinidae).

A peculiar, large scale (up to 3 mm. in diameter), white, circular, usually concealed by the epidermis of the hostplant (of mining habit), exuvia marginal or submarginal; parthenogenetic. Body top-shaped, anterior parts dorsally sclerotized, pygidium with a clavate sclerosis extending obliquely forward and outward from the inner edges of the heavy median lobes.

Records of *Howardia prunicola* (Maskell) have appeared in our literature, but the species is not established here.

Genus **KUWANASPIS** MacGillivray, 1921:311

Tsukushiaspis Kuwana, 1928.
Ferris, 1941:SIII–287.

Kuwanaspis pseudoleucaspis (Kuwana) (fig. 223).

Leucaspis bambusae Kuwana, 1902:74, pl. 13, figs. 75–81 (a homonym).
Chionaspis pseudoleucaspis Kuwana, 1923:323.
Ferris, 1941:SIII–288.

Oahu.

Immigrant. An Asiatic species. Although it has been known in Hawaii for some years, the only record of it in local literature in my files is that by Fullaway (1932: 106).

Hostplant: *Phyllostachys* (bamboo).

Female scale long, narrowed cephalad, white, exuvia at anterior end. The body of the female is conspicuously elongate, broadest behind.

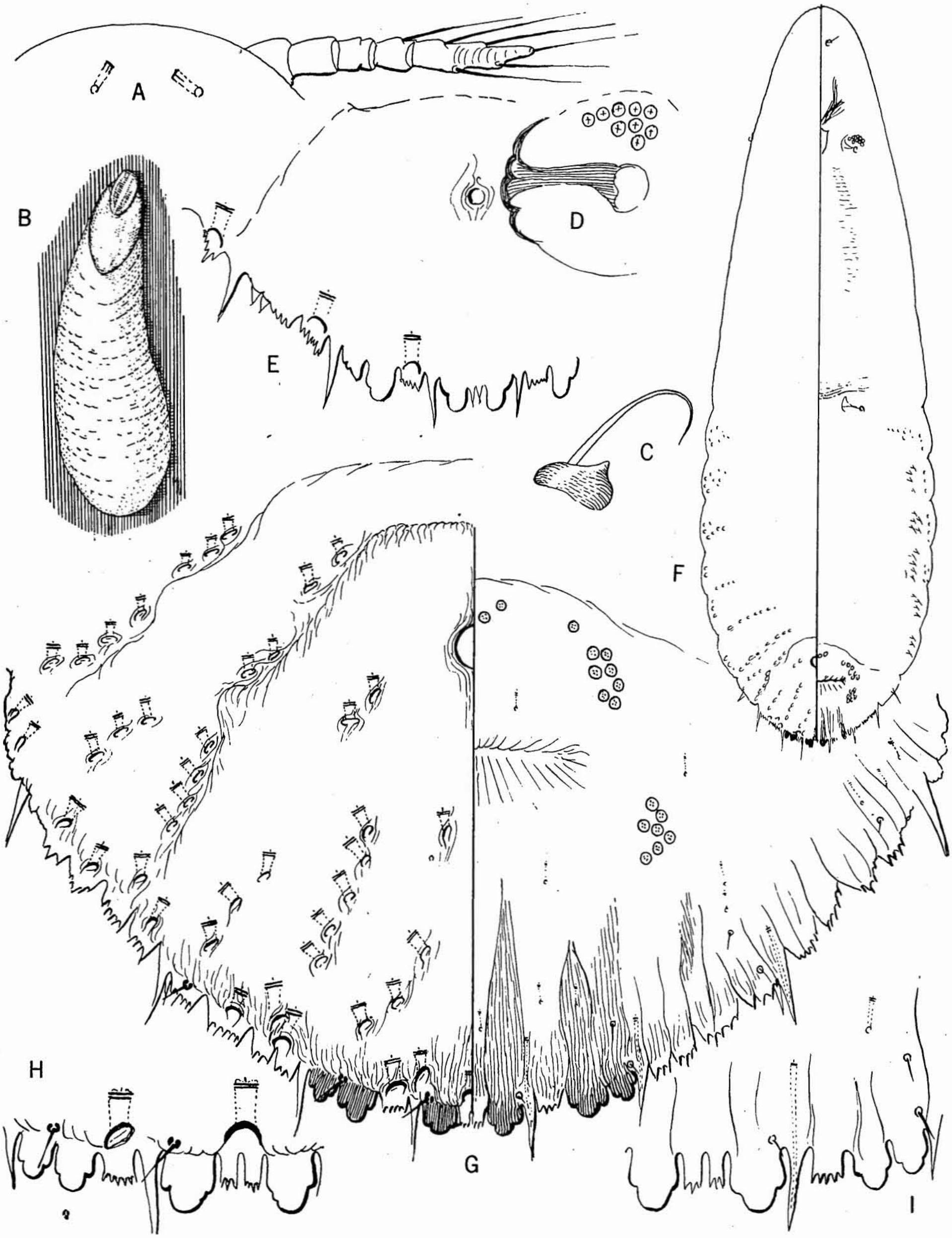


Figure 223—*Kuwanaspis pseudoleucaspis* (Kuwana).

Genus **DIASPIS** Costa, 1828

Ferris, 1937:SI–31.

Key to the Species Known to Occur in Hawaii

(Recast from Ferris.)

1. Median pygidial lobes with their mesal margin scarcely or not at all longer than their free lateral margin, lobes therefore projecting completely from apex of pygidium and not forming a median emargination or notch and of about same size as other lobes; prosoma without lateral lobes; on cacti .... **echinocacti** (Bouché).
   Median pygidial lobes with mesal margin definitely longer than free lateral margin, frequently two or three times as long, lobes usually projecting but little from apex of pygidium and therefore forming a distinct median notch, and distinctly larger than other lobes; prosoma normally with developed "ear-like" lobes on side margins, but these are variable and may or may not be present.................. 2
2. Pygidium with a series of about six large ducts anterior to marginal series from cephalad of second lobe to beyond fourth lobe; on pineapple................**bromeliae** (Kerner).
   Pygidium with only about two such large ducts, but a number of small ones; on orchids, palms and cacti............... .... **boisduvalii** Signoret.

The species name *Diaspis patelliformis* Sasaki, once used in Hawaiian literature, is no longer recognized here. While this text was in press, Dr. Morrison sent word that *Diaspis* (*Epidiaspis*) *conspicua* Brain was intercepted in quarantine at San Pedro, California, on "Araceae" from Hawaii on November 14, 1947, a new record for the Territory.

Diaspis boisduvalii Signoret (fig. 224).
Diaspis Boisduvalii Signoret, 1869:432, pl. 5, figs. 1, 2.
Ferris, 1937:SI–32.

Oahu, Maui.

Immigrant. Probably an American species, although described from orchids in Luxemburg; now widespread. First recorded from the Hawaiian Islands by Maskell, 1895:5.

Hostplants: *Cattleya,* cacti, coconut, *Dendrobium,* "orchids" (sometimes kills them).

Parasite: *Coccidencyrtus ochraceipes* Gahan (Hymenoptera: Encyrtidae).

Female scale circular, thin, flat, white, semitransparent; exuvia subcentral; male scale elongate, tricarinate, white.

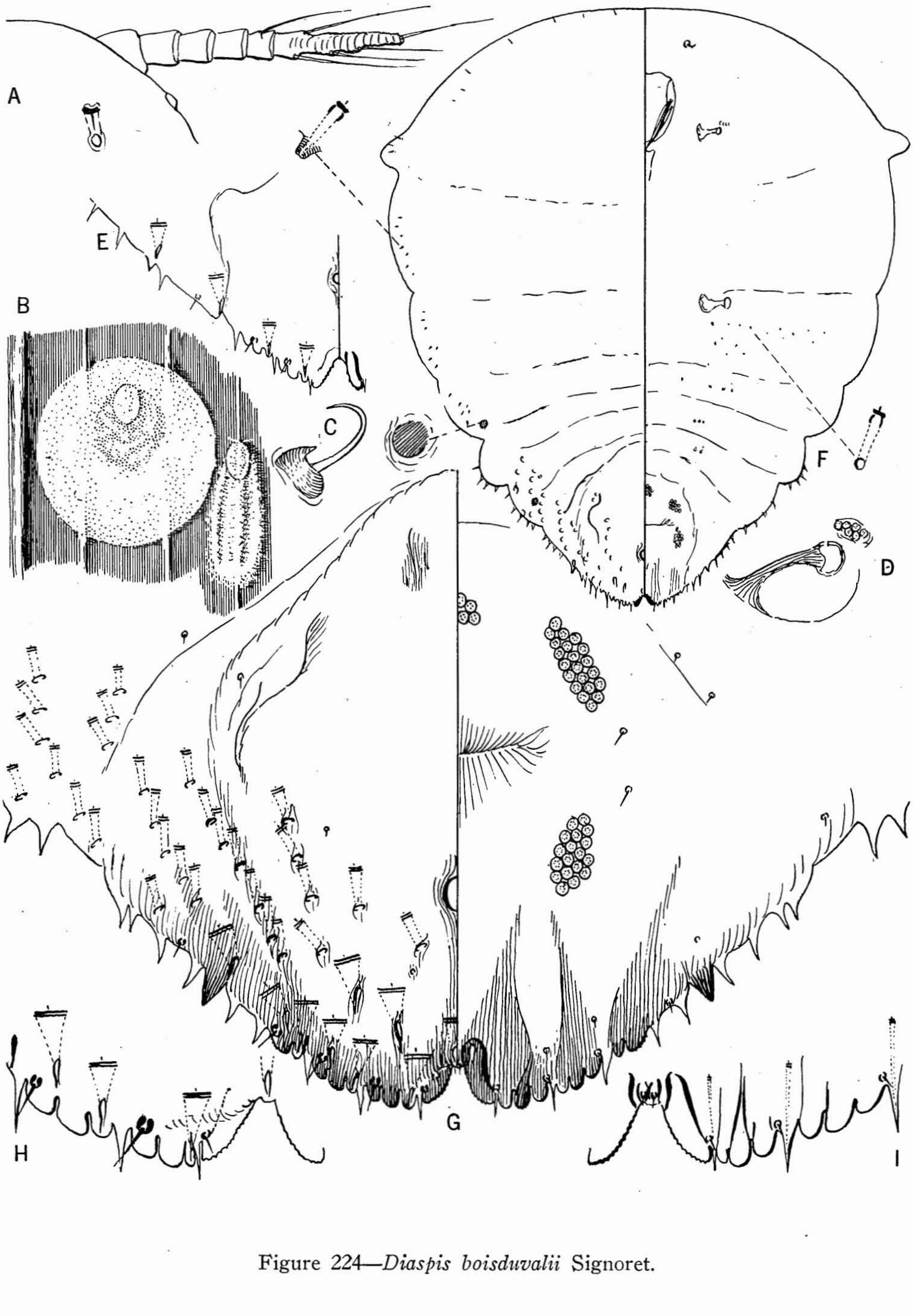


Figure 224—*Diaspis boisduvalii* Signoret.

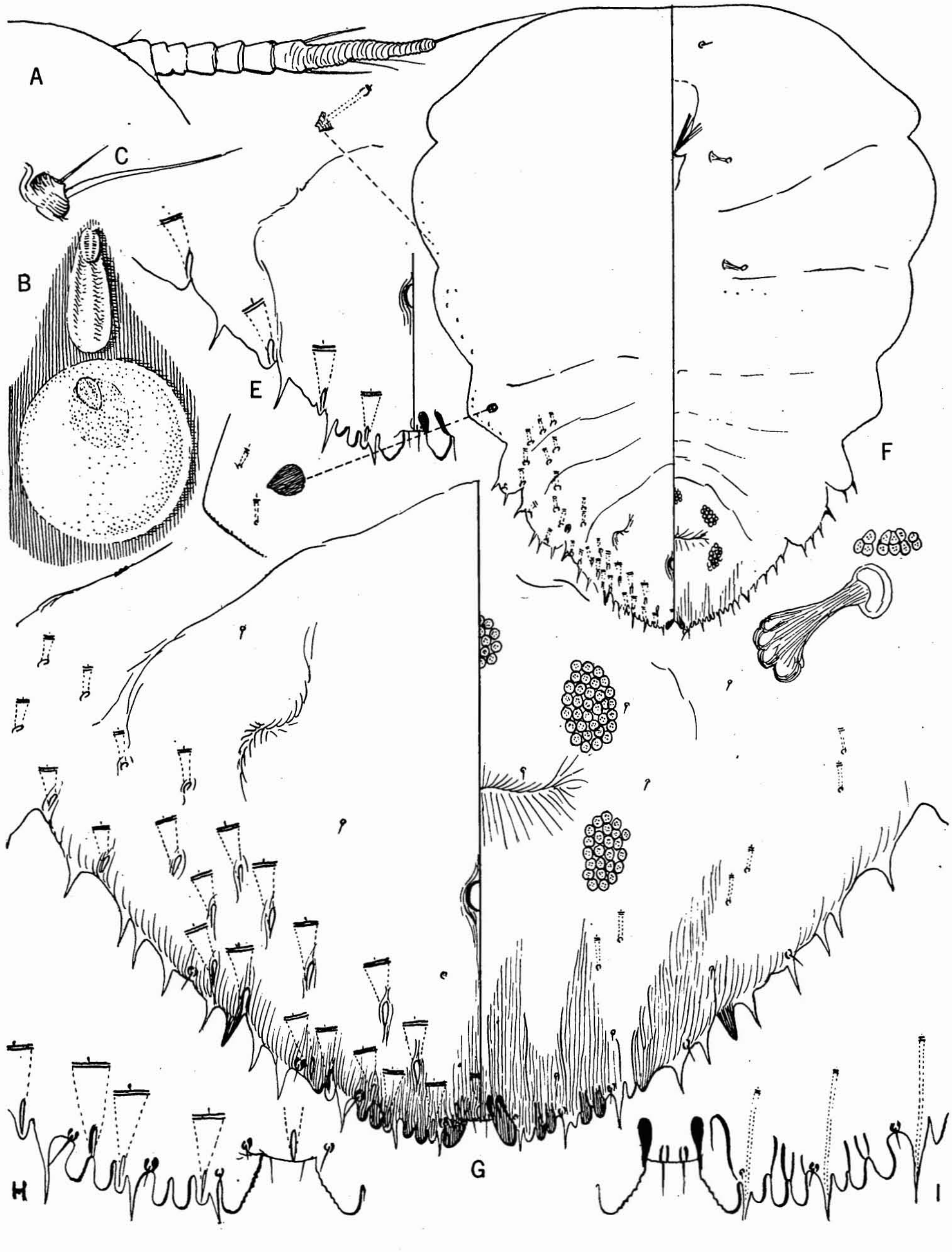


Figure 225—*Diaspis bromeliae* (Kerner), the pineapple scale.

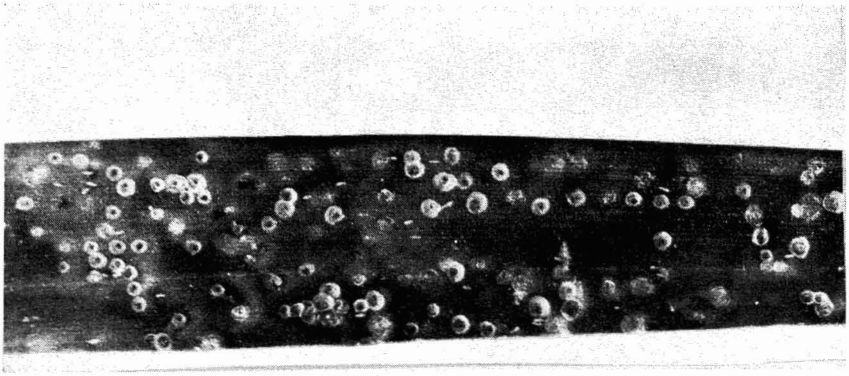


Figure 226—*Diaspis bromeliae* (Kerner), the pineapple scale on leaf of pineapple. (Photograph loaned by Walter Carter, Pineapple Research Institute.)

Diaspis bromeliae (Kerner) (figs. 225, 226).
Coccus bromeliae Kerner, 1778:20 (this reference was not examined by me).
Ferris, 1937:SI–33.

The pineapple scale.
Kauai, Oahu, Molokai, Lanai, Maui, Hawaii.
Immigrant. An American species now widespread over the world; in hothouses in the cooler regions. According to Kirkaldy (1904:229) the first specimens collected in Hawaii were taken by "Dr. Reh of Hamburg in 1902." Van Dine (1904:111) gave an early account of the species here.
Hostplant: pineapple.
Parasites: *Aphytis chrysomphali* (Mercet), *Aphytis diaspidis* (Howard), *Aspidiotiphagus citrinus* (Craw) (Hymenoptera: Aphelinidae).
Female scale of burrowing habit on leaves and fruit; circular, thin, white; exuvia subcentral; male scale white, tricarinate.
This species often is seen in abundance on pineapples, and it maintains itself on the drying planting material between harvest and replanting. It is not considered to be a serious pest in Hawaii, and it is kept within bounds by its several parasites.
Carter (1939:277) notes that it "produces a circular, chlorotic area which extends beyond the margins of the scale if feeding is prolonged. On rare occasions the circular, chlorotic spot is two or three times the diameter of the insect and obviously indicates a diffusion from the point of entry" of the phytotoxins injected while feeding.

Diaspis echinocacti (Bouché) (figs. 227, 228).
Aspidiotus echinocacti Bouché, 1833:52 (I have not examined this reference). Genotype of *Diaspis*.
Ferris, 1937:SI–36.

The cactus scale.
Oahu.

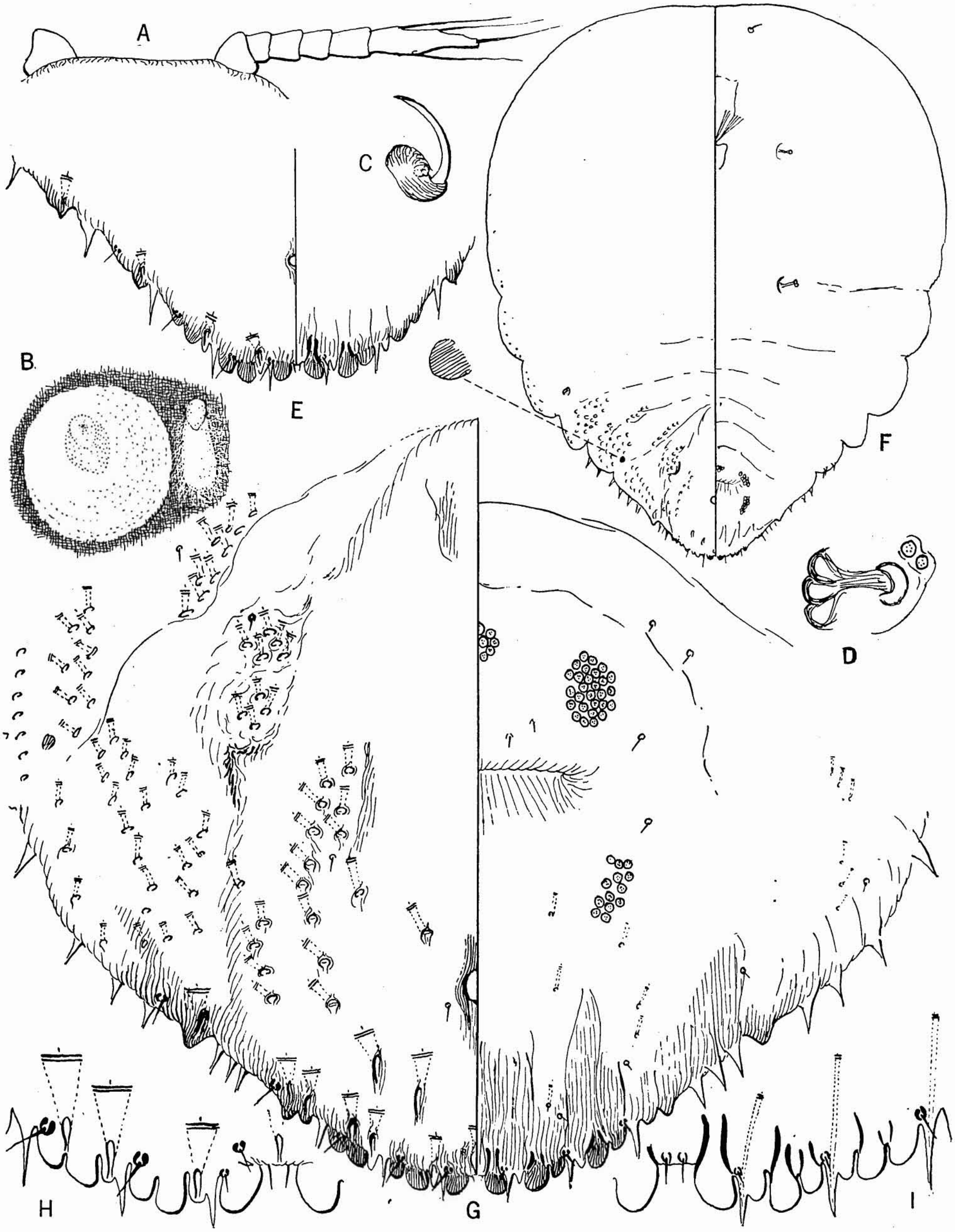


Figure 227—*Diaspis echinocacti* (Bouché), the cactus scale.

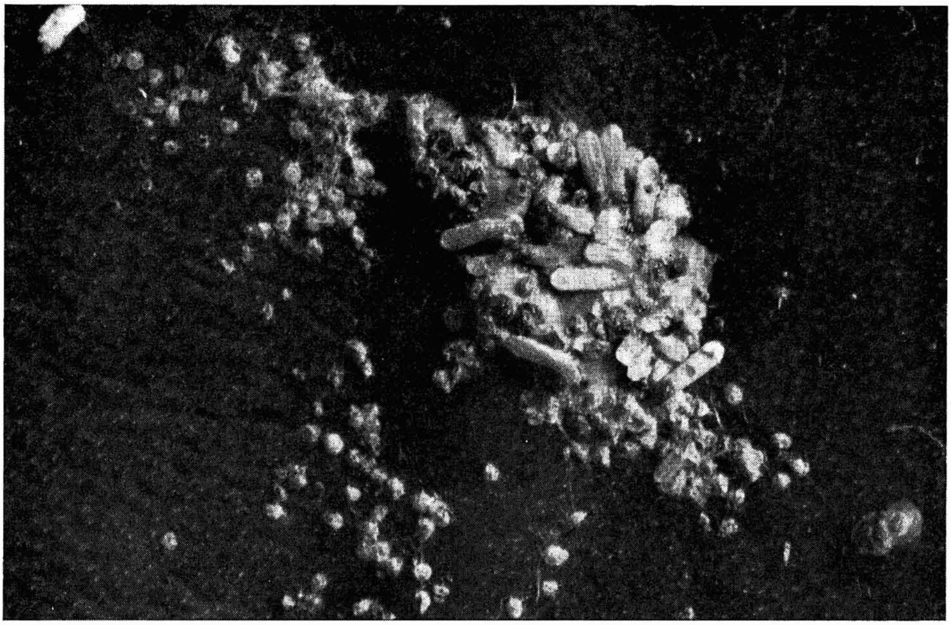


Figure 228—*Diaspis echinocacti* (Bouché), the cactus scale.

Immigrant. An American species which is now artificially spread to many parts of the world. First listed from Hawaii by Kotinsky (1910:128).

Hostplants: cacti (*Cereus, Epiphyllum, Opuntia* and other genera).

Parasites: *Aphytis diaspidis* (Howard), *Aspidiotiphagus citrinus* (Craw), *Aspidiotiphagus agilior* Berlese (Hymenoptera: Aphelinidae); *Plagiomerus diaspidis* Crawford (Hymenoptera: Encyrtidae).

Predator: *Aleurodothrips fasciapennis* (Franklin) (Thysanoptera: Phlaeothripidae).

Female scale circular, flat, white; exuvia central or subcentral, darker; male scale white, felted. It may at times become so abundant as almost to cover parts of the hostplant.

Genus **LEPIDOSAPHES** Shimer, 1868

Ferris, 1937:SI–70.

All of the scales of this group are elongate oyster-shaped and are frequently referred to as the oyster-shell scales.

The early Hawaiian records of *Lepidosaphes pomorum* (Bouché) may have been based upon quarantine material, for the species is not known to occur here now. I have omitted it from the list. There are some other species established here, but they have not been identified.

KEY TO THE SPECIES OF LEPIDOSAPHES REPORTED IN HAWAII

1. Head slightly or distinctly expanded on either side to form a lobe or slight antero-lateral expansion, expanded part vaguely resembling the head of certain planarian worms; prepygidial abdominal segments without sclerotized spurs or bosses 2
   Not such species, head region not at all expanded but evenly rounded 3

2(1). Median and posterior perivulvar pore groups with only about four to six pores in each; apex of pygidium comparatively subtruncate across first two pairs of lobes; on croton . . . . **tokionis** (Kuwana).
   Median and posterior perivulvar pore groups with about nine pores to each group; apex of pygidium comparatively pointed, apices of second lobes on a line near bases of first lobes; on orchids . . . . **mackieana** McKenzie.

3(1). Lateral lobes of abdominal segments 2, 3 and 4 each with a small, thorn-like spur on each antero-lateral angle (see fig. 231; do not confuse with marginal spines); mature females with derm of dorsa of thoracic and first abdominal segments heavily sclerotized . . . . **gloverii** (Packard).
   Lateral lobes of none of the abdominal segments with such spurs; derm of dorsum membranous at maturity 4

4(3). Abdominal segments 1, 2 and 4 each with a small, dorsal, sclerotized, boss-like process near each antero-lateral corner (see fig. 229); on *Citrus* . . . . **beckii** (Newman).
   Abdomen without such processes 5

5(4). On orchids; with a single dorsal macroduct (somewhat smaller than those along pygidial margin) slightly anterior to second pygidial lobes . . . . **noxia** McKenzie.
   On conifers (and *Araucaria* ?); without such a dorsal macroduct . . . . **pallida** (Maskell).

Lepidosaphes beckii (Newman) (figs. 229, 230).

Coccus Beckii Newman, 1869:217.

Ferris, 1937:SI–71.

The purple scale.

Kauai, Oahu, Molokai, Maui, Hawaii.

Immigrant. Cosmopolitan. First listed from Hawaii by Koebele (1898:109) (as *Mytilaspis citricola* Packard).

Hostplants: *Citrus*, coconut (?), lime, *Murraya exotica* (mock orange).

Parasites: *Aphytis chrysomphali* (Mercet), *Aspidiotiphagus agilior* Berlese, *Aspidiotiphagus citrinus* (Craw) (Hymenoptera: Aphelinidae).

Predators: *Lindorus lophanthae* (Blaisdell), *Chilocorus circumdatus* (Schönherr) and a species called "*Pentilia nigra* Weise" by Koebele, but misidentified and the species remains undetermined (Coleoptera: Coccinellidae).

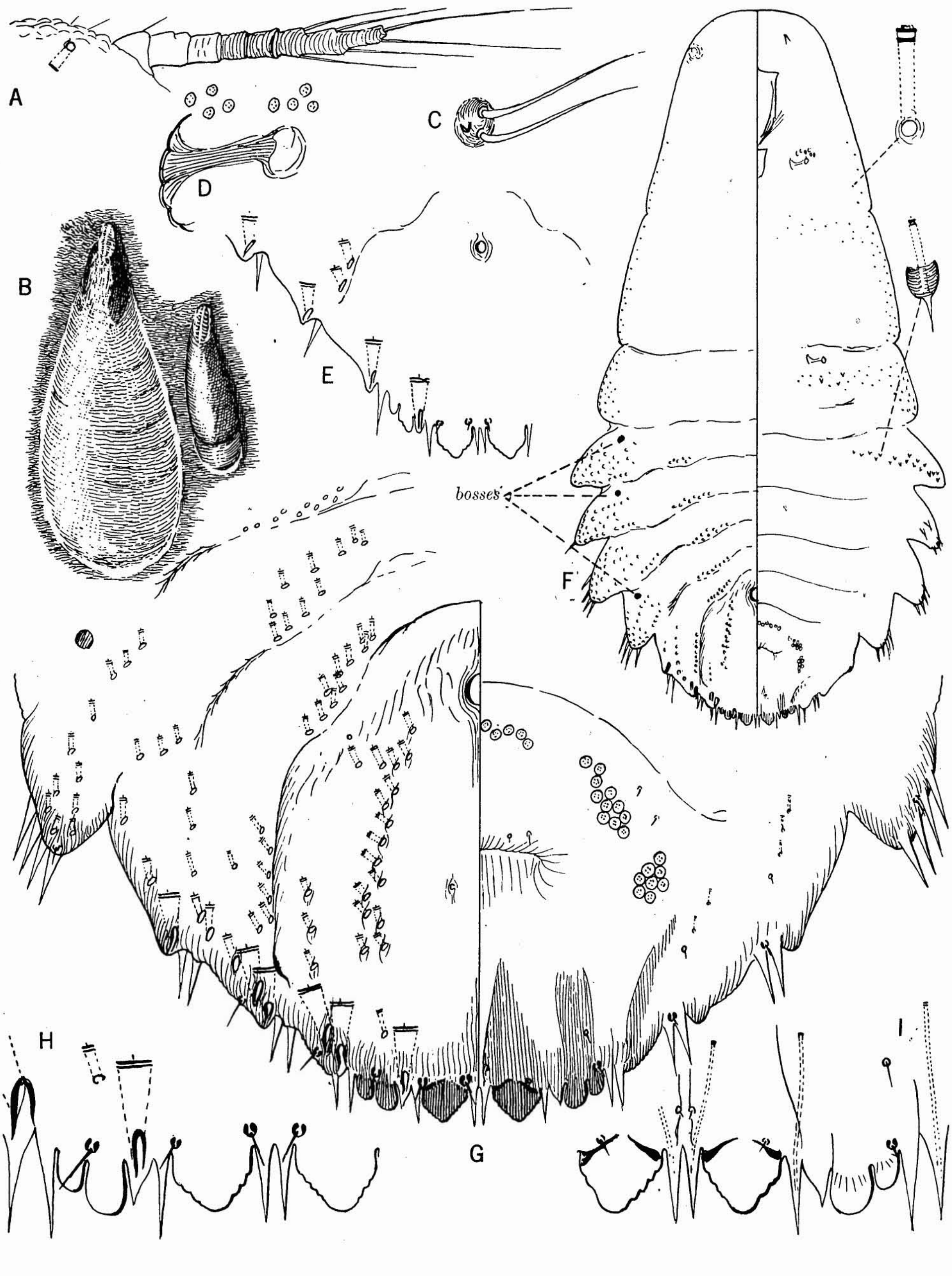


Figure 229—*Lepidosaphes beckii* (Newman), the purple scale.

Figure 230—*Lepidosaphes beckii* (Newman) on leaf of lime, above, and on *Murraya exotica*, below.

Male and female scales purplish or brownish; female scale 1.5–2.5 mm. in length, exuvia terminal.

This is a well-known, widespread pest of *Citrus*. The records of Kirkaldy (1902: 110; 1904:158) and others in Hawaiian literature of *L. pinnaeformis* (Bouché) apply to this species. Perkins (1897:500) noted that "Trees literally covered with *Mytilaspis* were entirely cleaned [by *Chilocorus circumdatus*]. Even the old dry scales were turned over in the search for food."

Lepidosaphes gloverii (Packard) (fig. 231).
Coccus gloverii Packard, 1869:527, fig. 528.
Ferris, 1937:SI–74.

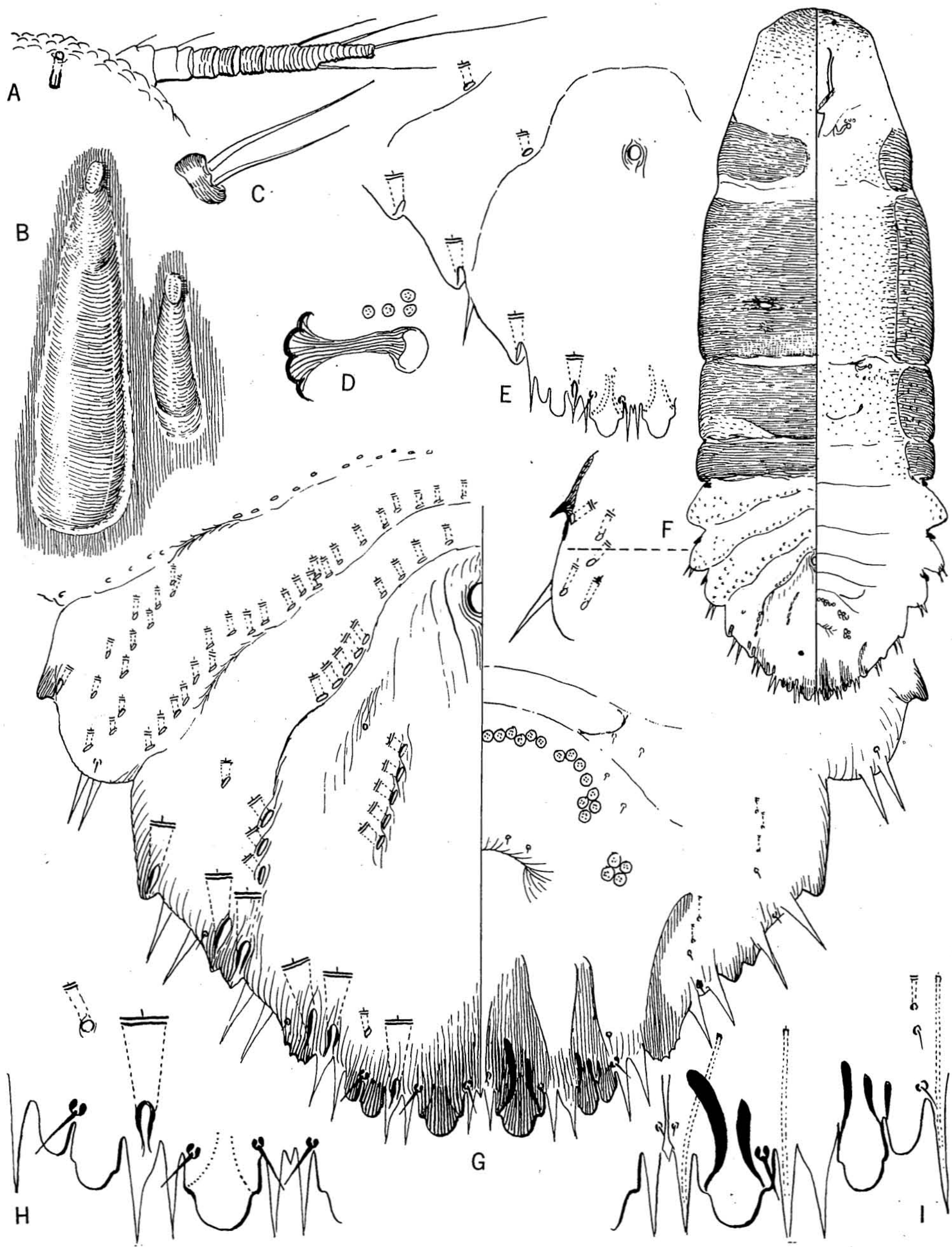


Figure 231—*Lepidosaphes gloverii* (Packard), Glover's scale.

Glover's scale.

Oahu.

Immigrant. Cosmopolitan; described from Florida. First recorded from Hawaii by Craw in 1896.

Hostplants: *Citrus,* croton.

Female scale reaches a length of 3 mm.; paler and more slender than *L. beckii.*

Lepidosaphes mackieana McKenzie (fig. 232).

Lepidosaphes mackieana McKenzie, 1943:153, fig. 6.

Oahu.

Immigrant. Evidently Oriental, but now known from the United States also. Part of the type series came from Honolulu. It has been intercepted on orchids from the Philippines and Singapore (?) in quarantine at Honolulu in recent years and has only recently been reported as established here.

Hostplants: *Dendrobium* orchids.

"Female scales occurring under the sheath on stems just above the crown of plant; males usually located further up on orchids under spike sheaths. Scale of female average 1¼ mm. long 1/3 mm. wide, pale brown, exuvium terminal; male resembles the female in color, except possibly slightly lighter, exuvium terminal." (McKenzie, 1943:154.)

Lepidosaphes noxia McKenzie (fig. 233).

Lepidosaphes noxia McKenzie, 1946:611, fig. 1. Correction to original description, Proc. Hawaiian Ent. Soc. 13 (1):31, 1947.

Oahu.

Immigrant. Native source undetermined, but described from orchids from Hawaii and California.

Hostplants: *Dendrobium dearei, Dendrobium* species.

Female scale "about 2.2 mm. long, pale brown, exuvium terminal; male smaller, much lighter in color than female, exuvium terminal." (From original description.)

This species has been troublesome to orchid growers for several years in Hawaii. It attacks the "leads of orchids concentrating particularly where the leaf partially surrounds the lead." (McKenzie.) There may be sufficient damage to the orchid tissues to kill the leaves.

Lepidosaphes pallida (Maskell).

"*Mytilaspis pallida* Green (var.?)" Maskell, 1895:7; 46.

Mytilaspis pallida Green, Indian Mus. Notes, 4:5, 1896.

Mytilaspis pallida variety *maskelli* Cockerell, American Naturalist 31:704, 1897. See Kotinsky, Proc. Hawaiian Ent. Soc. 1 (1):29, 1906, for notes.

This species is generally credited to Green, but Maskell first published a diagnosis of it, based upon examples from Honolulu (but originating in Japan).

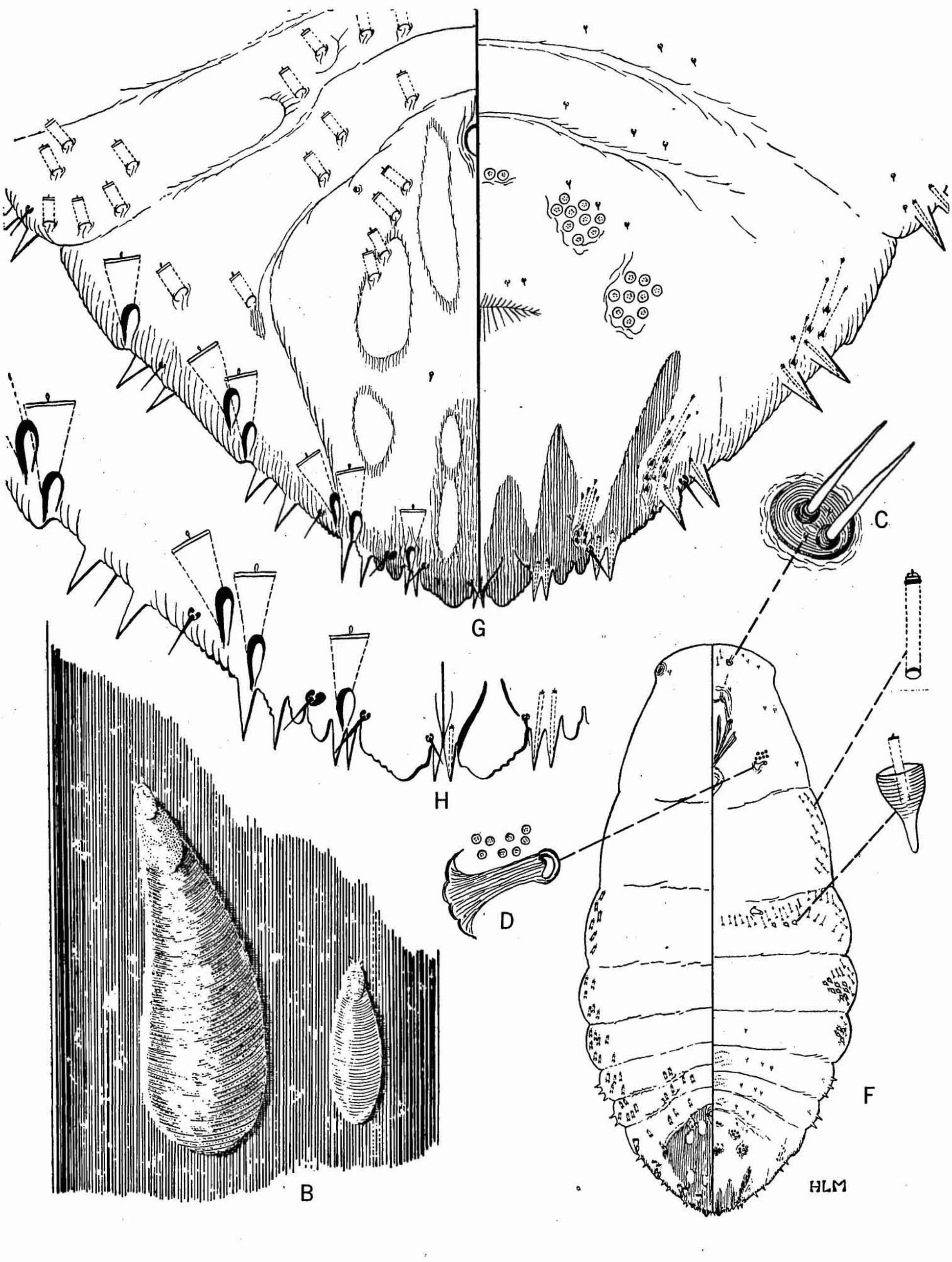


Figure 232—*Lepidosaphes mackieana* McKenzie, Mackie's scale. (Drawing loaned by McKenzie.)

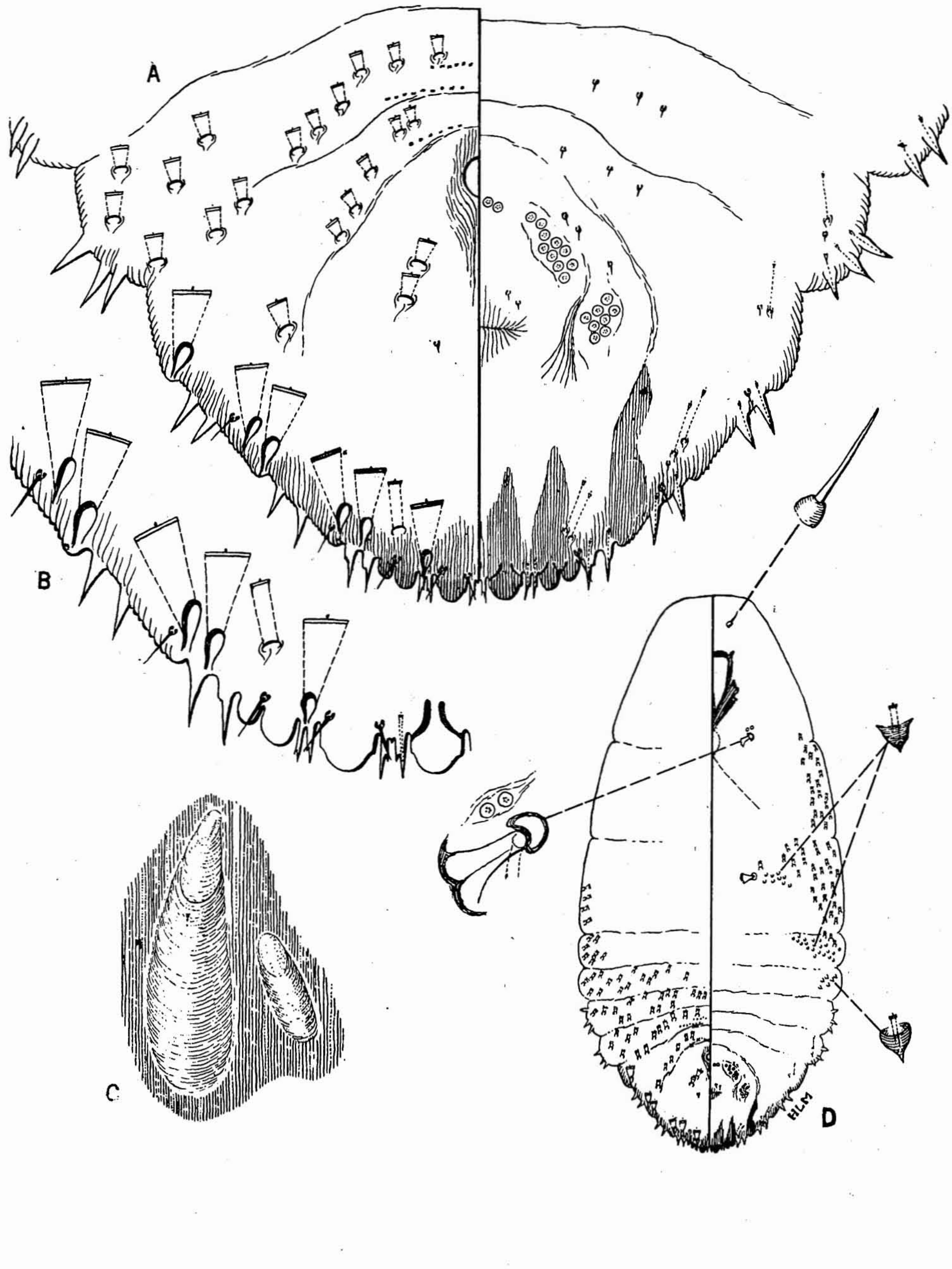


Figure 233—*Lepidosaphes noxia* McKenzie. (The antenna is damaged; it should have two unequal setae or, as in some examples, a third more slender seta in addition.) (After McKenzie.)

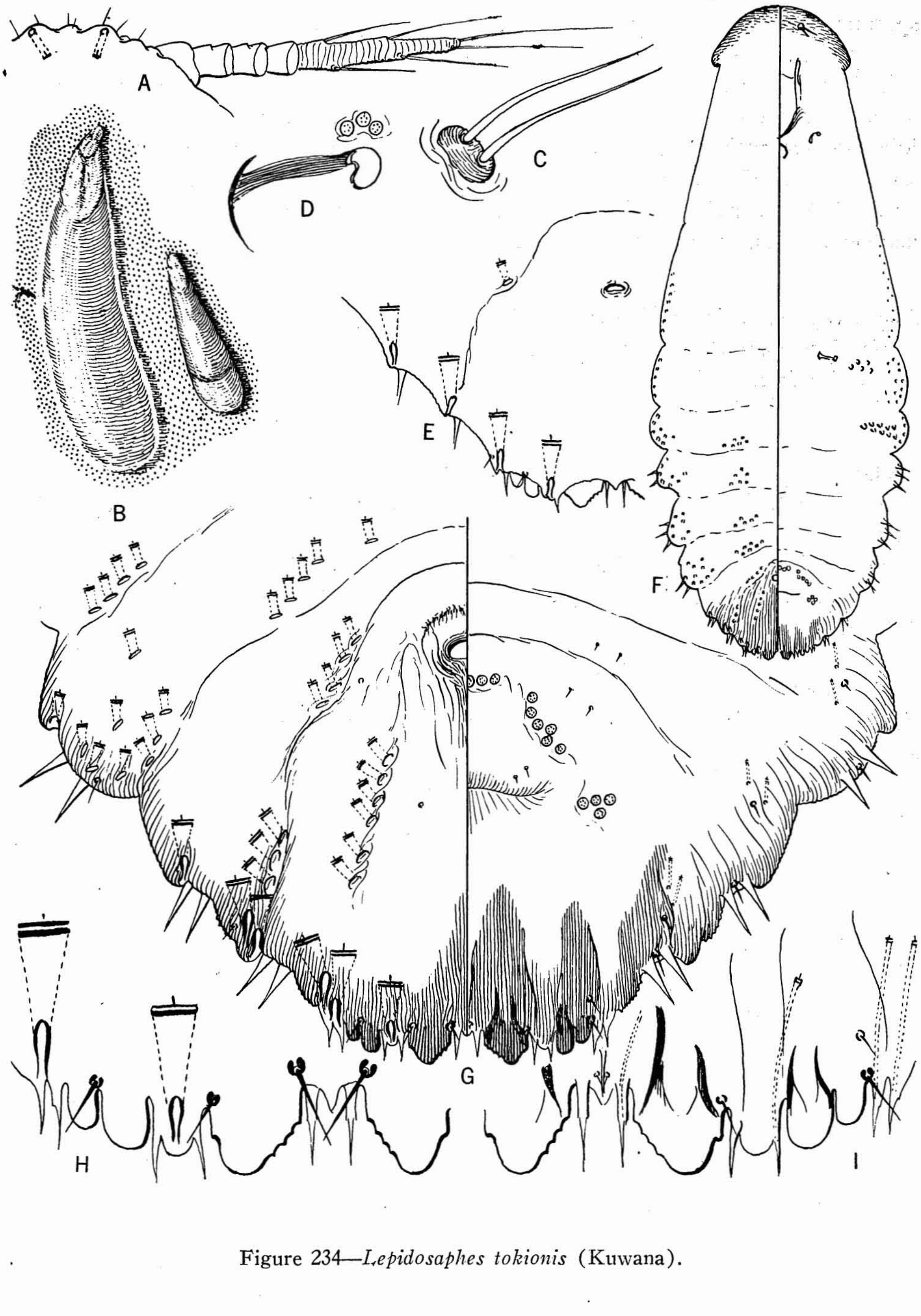


Figure 234—*Lepidosaphes tokionis* (Kuwana).

Oahu (?).

Immigrant. First listed from the Hawaiian Islands by Maskell (1895:46) from specimens taken from imported *Podocarpus* from Japan.

Hostplants: *Araucaria*, "juniper," *Podocarpus*.

This species should be removed from the Hawaiian list until we can show by authentic specimens that it does occur here. Maskell's material was taken at Honolulu (in quarantine?) from imported *Podocarpus*, but I have been unable to find any material of this species taken since the 1894 record. Some specimens have been labeled as *pallida* in local collections, but these have proved to be *tokionis* or another species, as yet undetermined.

Lepidosaphes tokionis (Kuwana) (fig. 234).

Mytilaspis newsteadi variety *tokionis* Kuwana, 1902:81.

Mytilaspis auriculata Green, 1907:205, pl. 21, figs. 14–16.

Ferris, 1938:SII–145 (misidentified as *L. lasianthi*); 1942:SIV–398.

Oahu.

Immigrant. Widespread. First listed from Hawaii (as *lasianthi*) by Kotinsky (1910:130).

Hostplant: croton (*Codiaeum variegatum*).

Parasites: *Aphytis chrysomphali* (Mercet), *Aspidiotiphagus citrinus* (Craw) (Hymenoptera: Aphelinidae).

Scales pale brown.

This common pest of crotons may be what Kirkaldy (1904:183) listed as *Lepidosaphes crotonis* (Cockerell). Also, it has been confused with and called *Lepidosaphes pallida* by some local workers.

Tribe ODONASPIDINI

The body of the adult female in this group is entirely enclosed both above and below by the usually thick scale, the characteristic diaspine pygidial lobes are wanting or are obscurely developed, and gland spines and plates are absent.

Genus **ODONASPIS** Leonardi, 1897

All of the known species of this group infest grasses.

Key to the Species Known in Hawaii

1. Anterior group of perivulvar pores present and containing between about 10 and 20 pores; on Bermuda grass and *Eragrostis* .... **ruthae** Kotinsky.
2. Anterior group of perivulvar pores absent; on bamboo...... .... **greenii** (Cockerell).

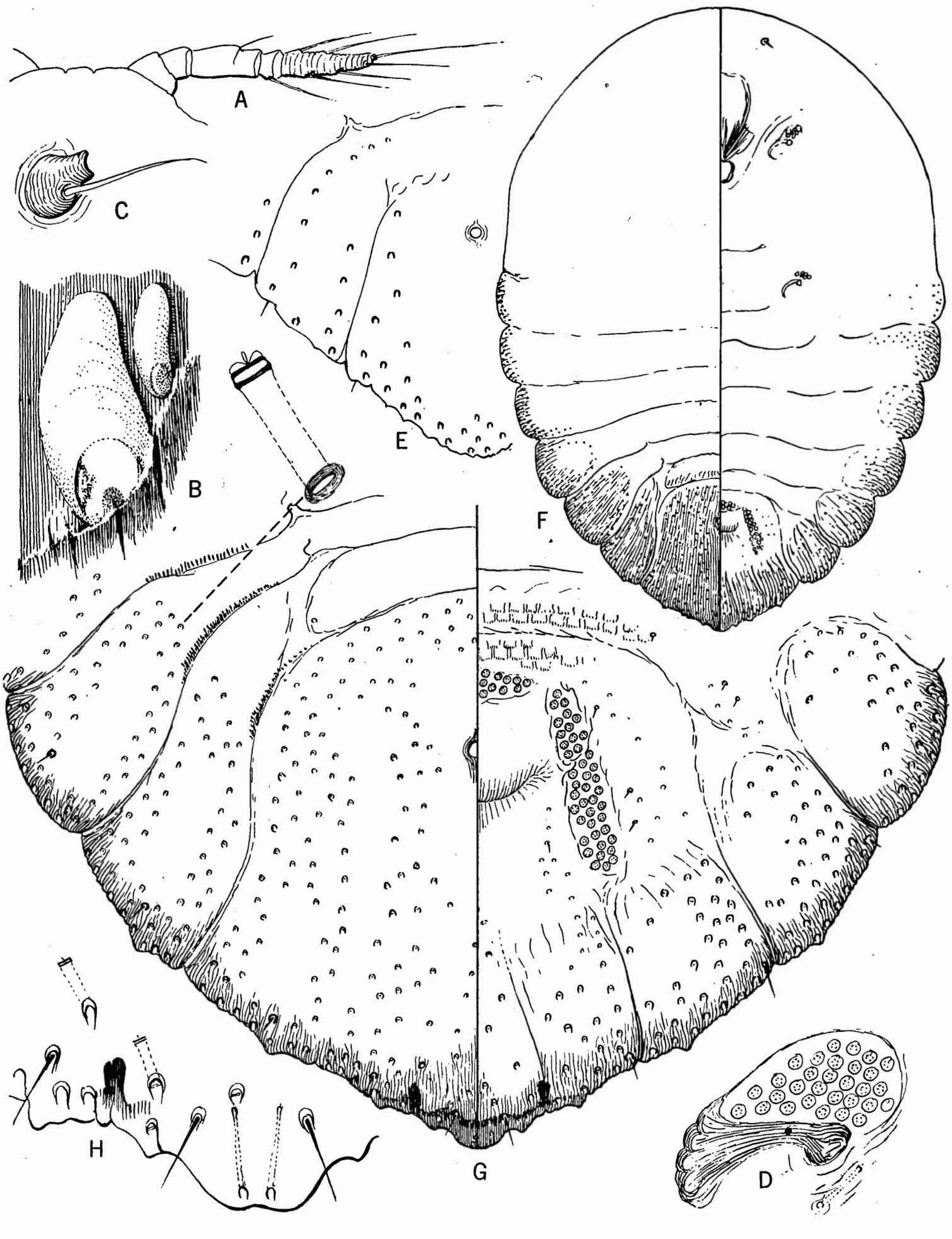


Figure 235—*Odonaspis ruthae* Kotinsky, Ruth's scale.

Odonaspis greenii (Cockerell).

Odonaspis secretus, variety *Greenii* Cockerell, 1902:25.

Green's scale.

Oahu, Hawaii.

Immigrant. Described from Ceylon and now known to be rather widespread. This species has been confused with *O. secreta* (Cockerell) in Hawaii, under which name it has appeared in our records. Kotinsky was the first to record it in Hawaiian literature (1910:129).

Hostplant: bamboo.

The absence of the anterior group of perivulvar pores together with a different body shape makes the species easy to distinguish from *ruthae*. Professor Ferris tells me that this species is extremely close to *Odonaspis secreta* (Cockerell), the only apparent difference being that in *secreta* the groups of perivulvar pores are connected anteriorly by a single line of pores, but in *greenii* they are separate.

Little is known about the species in Hawaii. It may be common beneath the dry bracts at the bases of branchlets, however.

Odonaspis ruthae Kotinsky (fig. 235).

Odonaspis ruthae Kotinsky, 1915:102, figs. 1, 2, 1910:129, description of second stage; misidentified as *O. graminis* Bremner. Ferris, 1938:SII–165.

Ruth's scale.

Oahu, Hawaii.

Immigrant. A widespread species. First noted in literature in Hawaii by Kotinsky in 1910 (p. 129, misnamed *O. graminis*).

Hostplants: Bermuda grass (*Cynodon dactylon*), *Eragrostis*.

Parasite: *Adelencyrtus odonaspidis* Fullaway (Hymenoptera: Encyrtidae).

The chalky white, oyster-shaped scales are found beneath the leaf sheaths and on the underground parts of the stems of the hostplants, but not on the roots.

No type locality was given by Kotinsky, but I presume that his material was collected at Honolulu, where he first saw it. The species is named after his daughter, Ruth.

Subfamily PHOENICOCOCCINAE Stickney, 1934:26

This is a peculiar group. It differs in many ways from the other diaspids. No scale composed of secretion-surrounded exuvia is formed. the adult female is enclosed in the sclerotized exuvia of the second stage, the pygidium does not contain any body segments cephalad of the sixth abdominal segment, and it is quite unlike that of other diaspids.

The group has been the subject of a detailed report by Stickney (1934) which should be consulted for detailed discussion. The remarks of Ferris (1942:SIV–446) are also worthy of careful notice. There is one contained tribe. Professor Ferris has supplied the following diagnosis:

Because of the diversity of form displayed by the members of this subfamily no brief characterization is possible; numerous exceptions and qualifications are necessary to account for all the known species. However, the three species recorded from the Hawaiian Islands fall nicely into a common type. For the recognition of these three species the following statement is offered:

Coccoidea in which the legs are lacking and the antennae are reduced to mere unsegmented tubercles in all stages after the first. Derm of the second stage becoming strongly sclerotic, and at maturity enclosing the adult female and even one or more immature stages. Posterior end of the second stage with a dorsal operculum, which encloses the anus and which ruptures about its margin to permit egress of the larvae. Adult female almost entirely membranous, body terminating at most in a weakly sclerotized plate or area showing no evidence of segmentation. Vulva beneath the pygidium, concealed by a membranous median lobe which is longitudinally folded or striate.

All the species of this subfamily except four occur on palms; the three recorded Hawaiian species are palm-infesting. They may occur almost anywhere on the host, exposed on the surface of the leaves, or buried deep in the leaf folds, or about the fruit, or even deeply concealed beneath the bases of the leaves, as is the case with the date-palm-infesting species from which the group derives its subfamily name.

Tribe PHOENICOCOCCINI Stickney, 1934:26

The keys herein are combinations of details assembled by Stickney with additional information supplied by Ferris.

Key to the Genera Represented in Hawaii

1. Scale thick; body broad cephalad, anterior extremity rounded, narrowed to pygidium or elliptical; 8-shaped pores scattered over venter at least; antennae each with four or five differentiated fleshy setae; exuvia of second stage more or less swollen and seed-like, anterior extremity rounded, posterior extremity narrowed and produced; margins of body with a zone of minute points......... **Palmaricoccus** Stickney.
2. Scale long and thin; body narrowed to head, anterior extremity produced; 8-shaped pores mostly localized along mid-ventral region; antennae each with at most two fleshy setae; exuvia of second stage flattened, its anterior extremity produced into a point; derm smooth, without a marginal zone of minute points...................... **Platycoccus** Stickney.

Genus **PALMARICOCCUS** Stickney, 1934:49

This genus is known from Oceania and America only. Two of the five described species have been found in Hawaii, but they are almost unknown to local workers. Ferris has added the following details:

Genotype: *Palmaricoccus attaleae* Stickney. As at present understood the genus contains three species, two of which occur in the Hawaiian Islands.

Phoenicococcinae in which the second stage is more or less swollen, with the cephalic extremity rounded and not produced, the caudal extremity, including the opercular area and two preceding segments, narrowed and more or less produced. Margins of the body bearing a zone of small points mingled with minute ducts. Adult female with the anterior extremity of the body rounded, not at all produced.

It is possible that the name *Palmaricoccus* will have to be abandoned as a synonym of *Colobopyga* Brethes, since the type of the latter definitely belongs to this group. However, there is also the possibility that two genera should be recognized, in which case certain species now referred to *Palmaricoccus* would be transferred to *Colobopyga,* but *Palmaricoccus* would be retained for its type and for the two Hawaiian species now referred to this genus.

Key to the Palmaricoccus Found in Hawaii

1. Body about 1.10 mm. long, 0.75 mm. broad, suboval to pyriform in shape; several antennal setae at least three times as long as an antenna; 8-shaped pores numerous, 300 or more; exuvia of second stage without such an apical point as described for *nesiotes;* spiracles each with a large cluster of pores; adult female with the pygidium broadly rounded... .... **pritchardiae** Stickney.
2. Body less than 0.75 mm. long and about 0.30 mm. broad, elongate-elliptical in shape; no antennal setae more than twice as long as antenna; 8-shaped pores much less abundant, not more than 60; exuvia of second stage with a distinct, median, hyaline point at posterior end of body, this projecting beyond the sclerotized region that encloses the operculum; spiracles with not more than four or five associated pores; adult female with the pygidium acutely pointed... .... **nesiotes** (Laing).

Palmaricoccus nesiotes (Laing) (fig. 236).

Halimococcus nesiotes Laing, 1925:51, fig. 1, a–c.

Palmaricoccus nesiotes (Laing) Stickney, 1934:72, figs. 1c, 21–26.

Oahu.

Immigrant. Described from a palm from Lord Howe Island (between Australia and New Zealand). First collected in Hawaii by Kotinsky in 1906. No further records are available.

Hostplant: "palm" (on leaves).

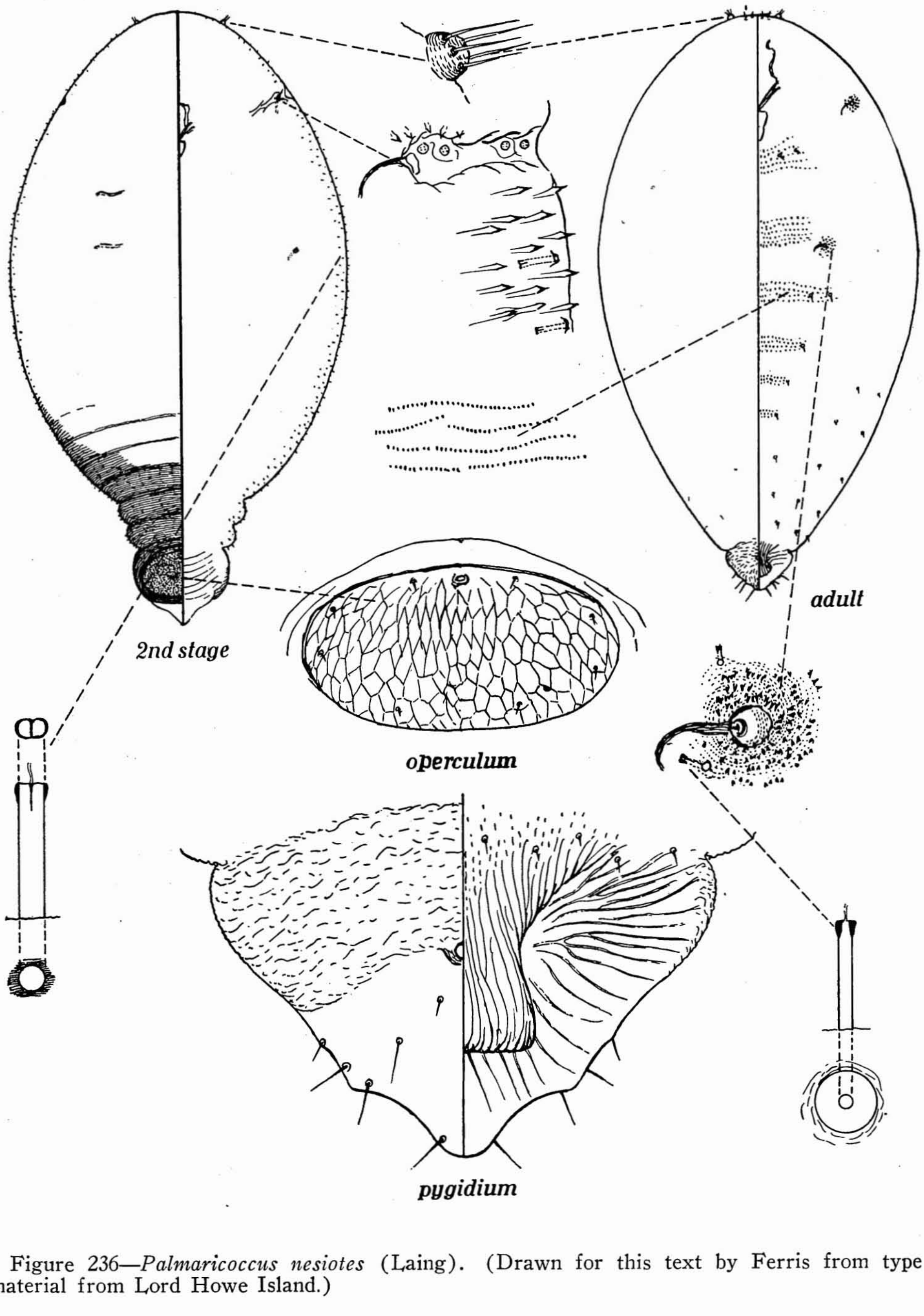


Figure 236—*Palmaricoccus nesiotes* (Laing). (Drawn for this text by Ferris from type material from Lord Howe Island.)

The Hawaiian locality "Macheno" given by Stickney appears to be a misspelling; we do not recognize it. It might refer to Makena, a valley in the Waianae Mountains.

Ferris supplies the following data:

Habit: According to Laing the insects occur on the leaves, the second exuvium having "a closely felted, cottony covering composed of very short fibers." Freed of their waxy covering they are dark-brown, narrowly oval, seed-like bodies.

Recognition characters: Second exuvium about 0.75 mm. long, as flattened on slide, oval, with opercular area and two preceding segments narrowed and defined by slight intersegmental constrictions. Faint lines indicate three or four more intersegmental lines anterior to these. Derm very strongly sclerotized at maturity, the sclerotization concealing minute structures. Posterior end of body terminating in a hyaline point. In specimens in which sclerotization has not proceeded to completion it can be seen that margins of body bear a narrow zone of small points which are mingled with very small tubular ducts and such ducts are scattered over entire body. Operculum transverse, rather narrowly oval, its derm showing a pattern of more or less hexagonal lines. Antennae very small, close to apex of head. Anterior spiracles close to margin of body and set in a slight furrow which bears three or four multilocular pores. Posterior spiracles set more toward midline of body, without a furrow and with but one or two pores.

Adult female slightly smaller than second stage and of much the same shape. Pygidium acutely pointed, margins slightly sculptured and bearing several quite long setae. Anterior portion of pygidial plate marked by faint, transverse, vermiculate lines; posterior portion smooth and slightly sclerotized. Ventral side of pygidium with a narrow, medially constricted lobe which covers vulva and laterad of this lobe are radiating, slightly sclerotized lines. Antennae with several setae, similar in form to antennae of second stage. Spiracles surrounded by small areas bearing concentric irregular lines of minute points. In midregion of body are small areas on thoracic and anterior abdominal segments, beset with lines of smaller points. Scattered over body, especially in region of spiracles, are a few minute ducts.

Palmaricoccus pritchardiae Stickney (fig. 237).

Palmaricoccus pritchardiae Stickney, 1934:67, figs. 1b, 18–20.

Oahu, Molokai (type series from both islands).

Immigrant, but not yet known elsewhere. Swezey found the first specimens in 1916 in the Punaluu mountains, Oahu.

Hostplants: on the fruits of *Pritchardia hardyi, Pritchardia rockiana* (fan palms; Hawaiian name, "loulu").

Ferris has prepared the following notes:

Mounted specimens are at hand from *Pritchardia* from Molokai; from "loulu palm," Castle Trail, Oahu, IX, 4, 1911, G. P. Wilder, collector; and from "loulu palm," Honolulu, Oahu, June 11, 1916, Swezey, collector.

Habit: Described by Stickney as occurring on the fruit.

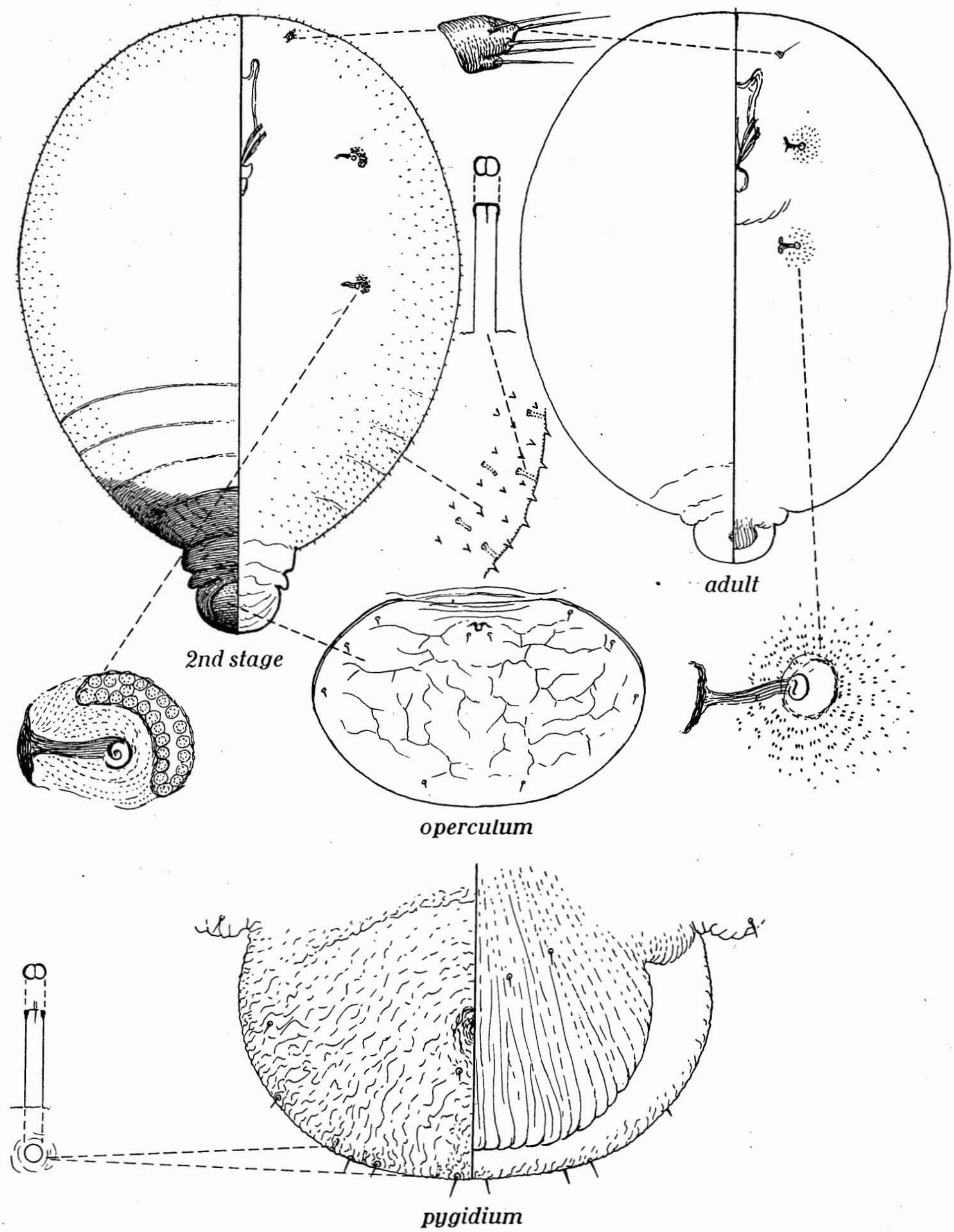


Figure 237—*Palmaricoccus pritchardiae* Stickney. (Drawn for this text by Ferris from type material from *Pritchardia* from Molokai.)

Recognition characters: Exuvia of second stage about 1.5 mm. long as mounted on slide, derm becoming very strongly sclerotized at maturity. Body oval, with narrowed terminal portion, which consists of area about operculum and two preceding segments, projecting posteriorly. Faint indications of three or four segmental lines appear anteriorly to this projection. In specimens taken before derm has become sclerotized there can be seen a marginal zone, extending almost entirely around body, which is beset with small points mingled with tubular ducts and such ducts are distributed generally over body. Spiracles set well in from margin of body, each with an associated, crescentic cluster of numerous pores. Operculum transverse, broadly oval, marked with a few irregular, branching furrows.

Adult female of same shape as second stage, but slightly smaller. Pygidium broadly rounded, its dorsum marked with faint, vermiculate sclerotized lines, its ventral side with a large, striated median lobe which conceals vulva, its margin with a few very small setae. Spiracles surrounded each by an area of very minute points arranged in irregularly concentric lines. Tubular ducts, all so very small that they can be detected only in well-stained preparations, are present in small numbers over body and along margin of pygidium.

Genus **PLATYCOCCUS** Stickney, 1934:107

This monotypic genus is known only from the Hawaiian Islands, but it is, I believe, an immigrant group. Ferris has written the following generic diagnosis.

Phoenicococcinae in which second stage is flattened and elongate, with head region more or less produced and acute, lateral margins of body with a narrow zone demarcated by a dark line that extends entirely about body. Derm in this stage without ornamentation and showing, dorsally, merely a few extremely minute, pore-like, clear markings. Antennae extremely minute, set at extreme anterior end of body. Spiracles very small, each with a single accompanying pore. Adult female of same shape as second stage; derm membranous. Pygidium very faintly marked by minute imbrications or vermiculations, ventral side with a large, longitudinally wrinkled median area which overlies vulva. Pygidium dorsally and ventrally with a few, small, scattered setae. Antennae set close to apex of prolonged head region, each apparently with but one or two very small setae. Spiracles surrounded each by an area of minute points which are arranged in irregularly concentric lines.

Platycoccus tylocephalus Stickney (fig. 238).

Platycoccus tylocephalus Stickney, 1934:108, figs. 1k, 40–46. Genotype.

Oahu (type locality: Honolulu).

Immigrant. Source unknown.

Hostplant: on leaves of *Pritchardia*.

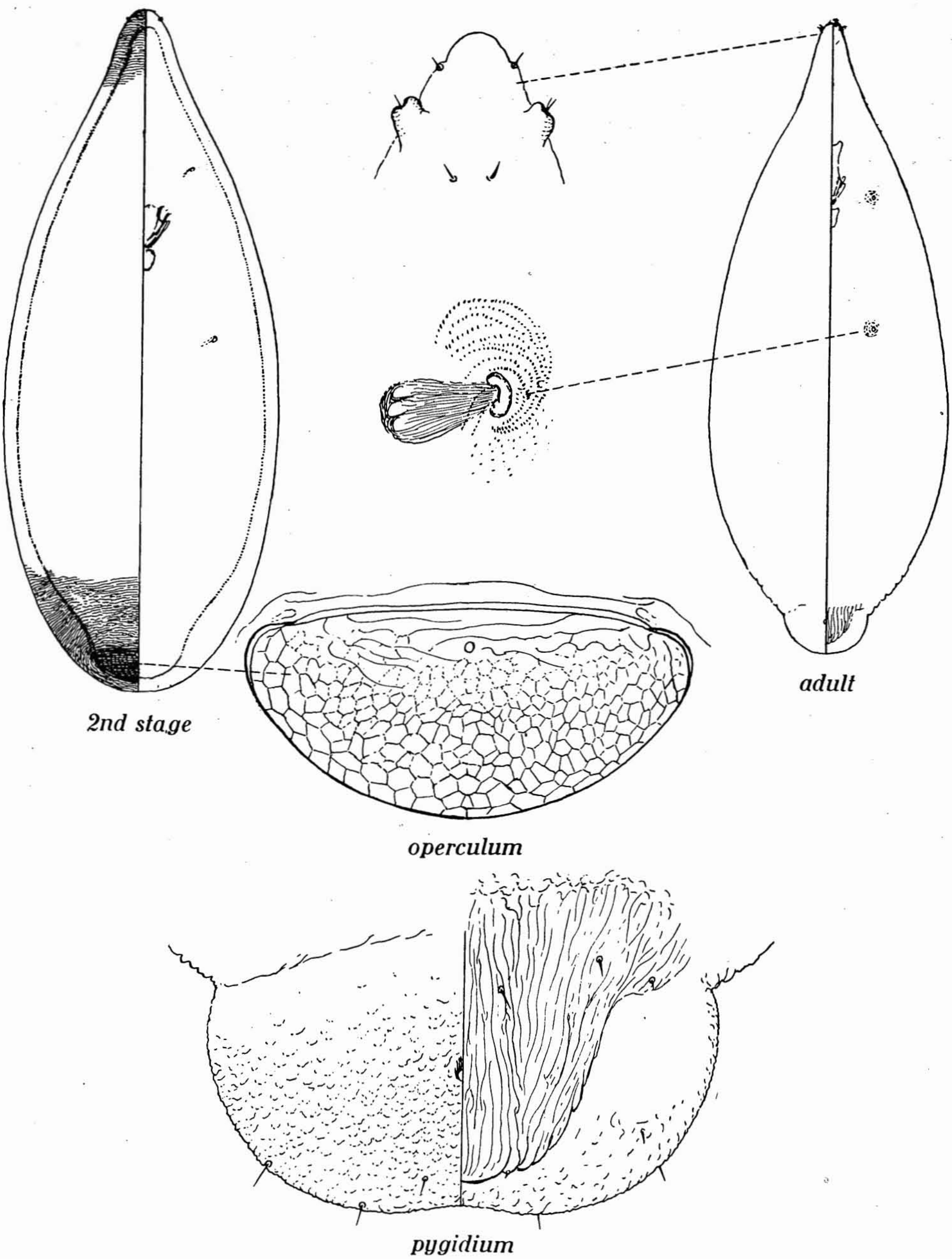


Figure 238—*Platycoccus tylocephalus* Stickney. (Drawn for this text by Ferris from type material from "palm" from Honolulu.)

In 1947, I found this species abundant on the leaves of a stunted *Pritchardia* palm growing on the windswept slopes traversed by the Waikane–Schofield Trail on Oahu. Only one plant was found infested in a series of plants in several groves inspected. The flat, elongate-oval, mature scales are reddish-brown in color and have the anterior end outlined by a narrow band of white wax. The large embryos, of which there may be about 20, are seen easily through the integument. They lie closely packed in a row down each side and at right angles to the median line of the body.

LITERATURE CONSULTED

ALFKEN, J. D.

1904. BEITRAG ZUR INSECTENFAUNA DER HAWAIISCHEN UND NEUSEELANDISCHEN INSELN. (Ergebnisse einer Reise nach dem Pacific. Schauinsland 1896–97). Zoologische Jahrbücher, Systematik 19:561–628, colored pl. 32.

ANDERSON, JAMES.

1790. MONOGRAPHIA COCCI CERIFERI. Madras. [Not seen.]

ASHMEAD, W. H.

1880. ON THE RED OR CIRCULAR SCALE OF THE ORANGE (CHRYSOMPHALUS FICUS RILEY MS.). American Entomologist 3:267–269, 1 fig.

——— 1882. ON THE APHIDIDAE OF FLORIDA, WITH DESCRIPTIONS OF NEW SPECIES. Canadian Entomologist 14 (4):88–93.

BAKER, A. C.

1920. GENERIC CLASSIFICATION OF THE HEMIPTEROUS FAMILY APHIDIDAE. U. S. Dept. Agr. Bull. 826: 1–109, pls. 1–16.

BANKS, C. S.

1906. THE PRINCIPAL INSECTS ATTACKING THE COCONUT PALM (PART II). Philippine Jour. Science 1 (3):211–228, pls. 1–10.

——— 1906. NEW PHILIPPINE INSECTS. Philippine Jour. Science 1 (3):229–238, pls. 1–11.

BEMIS, FLORENCE.

1904. THE ALEYRODIDS, OR MEALY-WINGED FLIES, OF CALIFORNIA, WITH REFERENCES TO OTHER AMERICAN SPECIES. Proc. U. S. National Mus. 27:471–537, pls. 27–37.

BIANCHI, F. A.

1941. THYSANOPTERA AND APHIDIDAE NEW TO THE ISLAND OF MIDWAY. Proc. Hawaiian Ent. Soc. 11 (1):37.

BOISDUVAL, J. B. A.

1869. NOTE SUR DEUX ESPECES NOUVELLES DE COCCIDES VIVANT SUR LES BAMBOUS CULTIVATES AU JARDIN DU HAMMA. Insectologie Agricole 3:260–262. [Not seen.]

BOUCHE, P. F.

1833. NATURGESCHICHTE DER SCHADLICHEN UND NUTZLICHEN GARTEN-INSECTEN UND DIE BEWAHRTESTEN MITTEL ZUR VERTILGUNG DER ERSTEREN. 1–176. Nicolai, Berlin. [Not seen.]

——— 1834. NATURGESCHICHTE DER INSECTEN BESONDERS IN HINSICHT IHRER ERSTEN ZUSTANDE ALS LARVEN UND PUPPEN. Erste Lieferung, i–v, 1–216, 10 pls. Nicolai, Berlin. [Not seen.]

——— 1851. NEUE ARTEN DER SCHILDLAUS-FAMILIE. Stettiner Entomologische Zeitung 12 (4):110–112.

BOYER de FONSCOLOMBE.

1841. DESCRIPTION DES PUCERONS QUI SE TROUVENT AUX ENVIRONS D'AIX. Ann. Soc. Ent. France 2: 157–198.

BRAIN, C. K.

1912. CONTRIBUTION TO THE KNOWLEDGE OF MEALY BUGS, GENUS PSEUDOCOCCUS, IN THE VICINITY OF CAPE TOWN, SOUTH AFRICA. Ann. Ent. Soc. America 5 (2):177–189, figs. 1–4, pls. 14–16.

BREDDIN, G.

1896. JAVANISCHE ZUCKERROHRSCHADLINGE AUS DER FAMILIE DER RHYNCHOTEN. Deutsche Ent. Zeitschrift 105–110.

BRITTON, W. E., et al.

1923. THE HEMIPTERA OR SUCKING INSECTS OF CONNECTICUT. In: Guide to the Insects of Connecticut. Part IV. Connecticut Geological and Nat. Hist. Survey Bull. 34:1–807, figs. 1–169, pls. 1–20.

BROWNE, E. T.

1887. NOTES ON A SPECIES OF ORTHEZIA FOUND IN KEW GARDENS. Jour. Quekett Microscopical Club (II) 3:169–172, pls. 16–17.

BRYAN, E. H., JR., and O. H. SWEZEY.

1926. HEMIPTERA. In: Insects of Hawaii, Johnston Island, and Wake Island. Bernice P. Bishop Mus. Bull. 31:80–81.

BUCKTON, G. B.

1876–1883. MONOGRAPH OF THE BRITISH APHIDES. 1:1–193, colored pls. 1–38 (1876); 2:1–175, colored pls. 39–86 (1879); 3:1–142, colored pls. 87–114 (1881); 4:1–228, colored pls. 115–134 (1883). Ray Society, London.

CALDWELL, J. S.

1940. NEW GENERA AND SPECIES OF JUMPING PLANT-LICE FROM THE HAWAIIAN ISLANDS WITH DESCRIPTIONS OF SEVERAL IMMATURE STAGES. Proc. Hawaiian Ent. Soc. 10 (3):389–397, fig. 1, pls. 22, 23.

CARNES, E. K.

1906. THE COCCIDAE OF CALIFORNIA. California State Commission of Horticulture 1–70, figs. 1–34, pl. 2, in color.

CARTER, WALTER.

1931. THE USE OF INSECTICIDES ON PINEAPPLE PLANTS IN HAWAII. Jour. Econ. Ent. 24 (6):1233–1242, pls. 51–52.

————

1932. BORDER PLANTINGS AS GUARD ROWS IN PINEAPPLE MEALY BUG CONTROL. Jour. Econ. Ent. 25 (5): 1027–1030, pls. 34–36.

————

1932. STUDIES OF POPULATIONS OF PSEUDOCOCCUS BREVIPES (CKL.) OCCURRING ON PINEAPPLE PLANTS. Ecology 13 (3):296–304.

————

1933. THE PINEAPPLE MEALY BUG, PSEUDOCOCCUS BREVIPES, AND WILT OF PINEAPPLES. Phytopathology 23 (3):207–242, figs. 1–12.

————

1933. THE SPOTTING OF PINEAPPLE LEAVES CAUSED BY PSEUDOCOCCUS BREVIPES, THE PINEAPPLE MEALY BUG. Phytopathology 23 (3):243–259, figs. 1–5.

————

1935. DIESEL OIL EMULSIONS AS INSECTICIDES. Jour. Econ. Ent. 28 (2):268–284, figs. 32–37.

————

1935. THE SYMBIONTS OF PSEUDOCOCCUS BREVIPES (CKL.). Ann. Ent. Soc. America 28 (1):60–64, pls. 1–4.

————

1936. INSECTS AND PLANT DISEASES. Proc. Hawaiian Ent. Soc. 9 (2):159–170, figs. 1–2.

————

1936. THE SYMBIONTS OF PSEUDOCOCCUS BREVIPES IN RELATION TO A PHYTOTOXIC SECRETION OF THE INSECT. Phytopathology 26 (2):176–183, figs. 1, 2.

————

1937. IMPORTATION AND LABORATORY BREEDING OF TWO CHALCID PARASITES OF PSEUDOCOCCUS BREVIPES (CKLL.). Jour. Econ. Ent. 30 (2):370–372, fig. 1.

————

1939. INJURIES TO PLANTS CAUSED BY INSECT TOXINS. Botanical Review 5 (5):273–326. [Contains an extensive bibliography.]

————

1942. THE GEOGRAPHICAL DISTRIBUTION OF MEALYBUG WILT WITH NOTES ON SOME OTHER INSECT PESTS OF PINEAPPLE. Jour. Econ. Ent. 35 (1):10–15, figs. 1–7.

————

1944. A STRIPING OF PINEAPPLE LEAVES CAUSED BY PSEUDOCOCCUS BREVIPES. Jour. Econ. Ent. 37 (6): 846–847, fig. 1.

————

1944. SOME INSECTS AND RELATED PESTS OF ORCHIDS. Pacific Orchid Soc. Hawaii 3 (4), no page numbers, figs. A–G.

———— and K. ITO.

1932. SOME EFFECTS OF PSEUDOCOCCUS BREVIPES (CKL.) ON PINEAPPLE FRUIT. Proc. Hawaiian Ent. Soc. 8 (1):37–39.

———— and CARL SCHMIDT.

1935. MASS ACTION PHENOMENA IN MEALYBUG WILT. Ann. Ent. Soc. America 28 (3):396–403, 2 figs.

CARY, L. R.

1903. PLANT-HOUSE ALEYRODES. Maine Agr. Expt. Station Bull. 96:125–144, figs. 43–51.

CHITTENDEN, F. H.

1906. THE MELON APHIS. U. S. Dept. Agr. Bureau Ent. Circular 80:1–16, figs. 1–6.

COCKERELL, T. D. A.

1893. COCCIDAE, OR SCALE INSECTS, WHICH LIVE ON ORCHIDS. The Gardeners' Chronicle (III) 13:548.

————

1893. TWO NEW SPECIES OF PULVINARIA FROM JAMAICA. Trans. Ent. Soc. London 159–163, 6 figs.

——— 1893. THE WEST INDIAN SPECIES OF DACTYLOPIUS. The Entomologist 26:177–179, 266–268, 1 fig.

——— 1894. NOTE ON DIASPIS LANATUS. Entomological News 5 (2) :43.

——— 1894. DESCRIPTIONS OF NEW COCCIDAE. Entomological News 5 (6) :203–204.

——— 1895. NOTES ON THE GEOGRAPHICAL DISTRIBUTION OF SCALE INSECTS. Proc. U. S. National Mus. 17: 615–625.

——— 1897. A NEW MEALY-BUG. Science Gossip (new series) 3:302.

——— 1898–1899. THE COCCIDAE OF THE SANDWICH ISLANDS. The Entomologist 31 (424) :239–240 (1898); 32 (431) :93 (1899); 32 (433) :164 (1899).

——— 1899. TABLES FOR THE DETERMINATION OF THE GENERA OF COCCIDAE. Canadian Entomologist 31 (10) :273–279; 31 (11) :330–333.

——— 1900. SOME COCCIDAE QUARANTINED AT SAN FRANCISCO. Psyche 9 (200) :70–72.

——— 1901. TABLE TO SEPARATE THE GENERA AND SUBGENERA OF COCCIDAE RELATED TO LECANIUM. Canadian Entomologist 33 (2) :57–58.

——— 1901. SOUTH AFRICAN COCCIDAE. The Entomologist 34 (459) :223–227.

——— 1902. NEW GENERA AND SPECIES OF COCCIDAE, WITH NOTES ON KNOWN SPECIES. Ann. Mag. Nat. Hist. (VII) 9 (49) :20–26.

COMSTOCK, J. H.
1881. REPORT OF THE ENTOMOLOGIST FOR 1880. In: Report of the Commissioner of Agriculture, U. S. Dept. Agr. 235–373, pls. 1–24.

——— 1883. SECOND REPORT OF THE DEPARTMENT OF ENTOMOLOGY OF CORNELL UNIVERSITY EXPERIMENT STATION. 46–162, figs. 1–15, pls. 1–6.

——— 1933. AN INTRODUCTION TO ENTOMOLOGY. i–xix, 1–1044, figs. 1–1228. Comstock Publishing Co., Ithaca, New York.

COQUEREL, CHARLES.
1859. NOTE SUR QUELQUES INSECTES DE MADAGASCAR ET DE BOURBON. Ann. Soc. Ent. France (III) 7: 239–260, pl. 6, fig. 3.

CRAW, ALEXANDER.
1896. A LIST OF SCALE INSECTS FOUND UPON PLANTS ENTERING THE PORT OF SAN FRANCISCO. U. S. Dept. Agr. (Tech. Series) 4:40–41.

CRAWFORD, D. L.
1914. A MONOGRAPH OF THE JUMPING PLANT-LICE OR PSYLLIDAE OF THE NEW WORLD. 85:1–182, 541 figs. Smithsonian Institution, U. S. National Mus., Washington, D.C.

——— 1918. THE JUMPING PLANT LICE (FAMILY PSYLLIDAE) OF THE HAWAIIAN ISLANDS. Proc. Hawaiian Ent. Soc. 3 (5) :430–456, pl. 8.

——— 1920. CEROTRIOZA. Proc. Hawaiian Ent. Soc. 4 (2) :374–375, 1 fig.

——— 1921. HONEY-DEW SMUT AND PHOTOSYNTHESIS. Proc. Hawaiian Ent. Soc. 4 (3) :539–550.

——— 1924. THE BISHOP MUSEUM COLLECTION OF PSYLLIDAE. Proc. Hawaiian Ent. Soc. 5 (3) :369–370.

——— 1925. NOTES ON HAWAIIAN PSYLLIDAE. Proc. Hawaiian Ent. Soc. 6 (1) :27–31.

——— 1927. PSYLLIDAE OF MOLOKAI. Proc. Hawaiian Ent. Soc. 6 (3) :423–424.

——— 1928. A NEW PSYLLID FROM MAUI. Proc. Hawaiian Ent. Soc. 7 (1) :33.

CURTIS, JOHN.
1843. ENTOMOLOGY.—NO. XLVIII. THE SMALL BROWN SCALE, ASPIDIOTUS PROTEUS. The Gardeners' Chronicle (Sept. 30) 676, figs. 1–8.

DAS, BASHAMBAR.
1918. THE APHIDIDAE OF LAHORE. (With notes and an introduction by P. van der Goot, Ed.) Mem. Indian Mus. 6:135–274, pls. 13–30.

DAVIDSON, J.
1925. A LIST OF BRITISH APHIDS (INCLUDING NOTES ON THEIR SYNONYMY, THEIR RECORDED DISTRIBUTION AND FOOD PLANTS IN BRITAIN AND A FOOD-PLANT INDEX). 1–176. The Rothamsted Monographs on Agricultural Science, London.

DAVIS, J. J.
1909. TWO NEW GENERA AND SPECIES OF APHIDIDAE. Ann. Ent. Soc. America 2 (1):196–200, pl. 27.

———
1914. NEW OR LITTLE KNOWN SPECIES OF APHIDIDAE. Canadian Entomologist 46:41–51; 77–87; 121–134; 165–173; 226–236.

DEGEER, CARL.
1773. MEMOIRES POUR SERVIR A L'HISTOIRE DES INSECTES. 3:i–viii, 1–696. Stockholm.

DEL GUERCIO, GIACOMO.
1908. CONTRIBUZIONE ALLA CONOSCENZA DEL LACNIDI ITALIANI. Redia 5:173–359, pls. 9–20 (containing 285 figs.).

———
1911. INTORNO ADUE GENERI DI AFIDIDI AMERICANI. Redia 7:462–464.

———
1916. CONTRIBUZIONE ALLA CONOSCENZA DECLI AFIDI. Redia 12:197–277, pls. 2–5.

DIETZ, H. T., and HAROLD MORRISON.
1916. THE COCCIDAE OR SCALE INSECTS OF INDIANA. Eighth Annual Rept. State Entomologist of Indiana, 195–321.

DOANE, R. W., and EVELYN HADDEN.
1909. COCCIDAE FROM THE SOCIETY ISLANDS. Canadian Entomologist 41 (8):296–300, figs. 8, 9.

DOUGLAS, J. W.
1887. NOTE ON SOME BRITISH COCCIDAE (NO. 6). Entomologist's Monthly Mag. 23:239–243.

———
1888. NOTE ON SOME BRITISH COCCIDAE (NO. 8). Entomologist's Monthly Mag. 24:165–171, figs. 1–4.

EHRHORN, E. M.
1900. NEW COCCIDAE FROM CALIFORNIA. Canadian Entomologist 32 (10):311–318, pl. 7.

———
1912. A FEW NOTES ON COCCIDAE. Proc. Hawaiian Ent. Soc. 2 (4):147–150, pl. 5.

———
1914. PSEUDOCOCCUS SPECIES FOUND ON SUGAR CANE IN HAWAII. Proc. Hawaiian Ent. Soc. 3 (1):1–3.

———
1916. CONTRIBUTIONS TO THE KNOWLEDGE OF THE DACTYLOPIINAE OF HAWAII. Proc. Hawaiian Ent. Soc. 3 (3):231–247.

ESSIG, E. O.
1929. INSECTS OF WESTERN NORTH AMERICA. i–ix, 1–1035, figs. 1–766. Macmillan Co., New York.

———
1935. CALIFORNIA APHIDIDAE, NEW CLOUDY VEINED SPECIES. Pan-Pacific Entomologist 11 (4):156–162, figs. 1–3.

———
1938. THE ORNATE APHID, NEW TO NORTH AMERICA. Pan-Pacific Entomologist 14 (2):92–95, fig. 1.

———
1938. APHIDS FEEDING ON CELERY IN CALIFORNIA. Hilgardia 11 (9):459–492, figs. 1–12.

———
1940. SOME SOUTH SEA ISLAND APHIDS. Jour. Econ. Ent. 33 (1):200–201.

———
1942. COLLEGE ENTOMOLOGY. i–vii, 1–900, figs. 1–826. Macmillan Co., New York.

———
1944. A NEW APHID ON GUAYULE AND NOTES ON OTHER SPECIES OF CEROSIPHA. Hilgardia 16 (4): 177–184, figs. 1–6.

FABRICIUS, J. C.
1794. ENTOMOLOGIA SYSTEMATICA. 1–349. Proft, Hafniae.

FERNALD, M. E.
1903. A CATALOGUE OF THE COCCIDAE OF THE WORLD. 1–360. Carpenter and Morehouse, Amherst, Massachusetts. [See SANDERS, J. G., 1906 and 1909, and SASSCER, E. R., 1911, 1912, 1913 and 1915, for supplements.]

FERRIS, G. F.
1917. METHODS FOR THE STUDY OF MEALY-BUGS. Jour. Econ. Ent. 10:321–325.

———— 1918. THE CALIFORNIA SPECIES OF MEALY BUGS. Stanford Univ. Pubs. (Univ. Series) 32:1–77, figs. 1–16, pls. 1–3.

———— 1919. OBSERVATIONS ON SOME MEALY-BUGS. Jour. Econ. Ent. 12 (4) :292–299, figs. 15–17.

———— 1935 (1939). SCALE INSECTS FROM THE MARQUESAS. In: Marquesan Insects—III. Bernice P. Bishop Mus. Bull. 142:125–131, figs. 1–3.

———— 1935 (1939). AN APPARENTLY UNDESCRIBED MEALYBUG FROM TAHITI. In: Marquesan Insects—III. Bernice P. Bishop Mus. Bull. 142:133–135, fig. 1.

———— 1937. ATLAS OF THE SCALE INSECTS OF NORTH AMERICA. First series, sections 1–136. Stanford Univ. Press, California.

———— 1938. ATLAS OF THE SCALE INSECTS OF NORTH AMERICA. Second series, sections 137–268. Stanford Univ. Press, California.

———— 1941. THE GENUS ASPIDIOTUS. Microentomology 6 (2) :33–70, figs. 19–26.

———— 1941. ATLAS OF THE SCALE INSECTS OF NORTH AMERICA. Third series, sections 269–384. Stanford Univ. Press, California.

———— 1942. ATLAS OF THE SCALE INSECTS OF NORTH AMERICA. Fourth series, sections 385–448. Stanford Univ. Press, California.

———— and G. E. MURDOCK.
1936. CONTRIBUTIONS TO THE KNOWLEDGE OF THE COCCOIDEA. III. ON CERTAIN DERMAL STRUCTURES OF THE PSEUDOCOCCIDAE. Microentomology 1 (4) :115–122.

———— and V. P. RAO.
1947. THE GENUS PINNASPIS COCKERELL. Microentomology 12 (2) :25–58, figs. 10–22.

FONSCOLOMBE. See BOYER DE FONSCOLOMBE.

FULLAWAY, D. T.
1909. INSECTS OF COTTON IN HAWAII. Hawaii Agr. Expt. Station, Bull. 18:1–27, figs. 1–18.

———— 1910. SYNOPSIS OF HAWAIIAN APHIDAE. In: Annual Rept. Hawaii Agr. Expt. Station for 1909. 20–46, figs. 1–8.

———— 1910. GEOCOCCUS RADICUM GREEN, IN HAWAII. Proc. Hawaiian Ent. Soc. 2 (3) :108–109, pl. 4.

———— 1912. LIST OF THE APHIDAE OF THE HAWAIIAN ISLANDS. Proc. Hawaiian Ent. Soc. 2 (4) :163–165.

———— 1913. PRELIMINARY LIST OF THE HYMENOPTEROUS PARASITES OF COCCIDAE AND APHIDAE IN HAWAII. Proc. Hawaiian Ent. Soc. 2 (5) :215–216.

———— 1918. THE CORN LEAF HOPPER. Board of Commissioners of Agr. and Forestry, Territory of Hawaii, Division Ent. Bull. 4:1–16, 18 figs.

———— 1920. NATURAL CONTROL OF SCALE INSECTS IN HAWAII. Proc. Hawaiian Ent. Soc. 4 (2) :237–246.

———— 1923. NOTES ON THE MEALY-BUGS OF ECONOMIC IMPORTANCE IN HAWAII. Proc. Hawaiian Ent. Soc. 5 (2) :305–321.

———— 1932. SYNOPSIS OF THE HAWAIIAN DIASPINAE. Proc. Hawaiian Ent. Soc. 8 (1) :93–110.

———— 1932. HYMENOPTEROUS PARASITES OF THE COCCIDAE, ETC., IN HAWAII. Proc. Hawaiian Ent. Soc. 8 (1) : 111–120.

GILLETTE, C. P.
1908. NEW SPECIES OF COLORADO APHIDIDAE, WITH NOTES UPON THEIR LIFE-HABITS. Canadian Entomologist 40:17–20; 61–68, pls. 1, 3.

———— and M. A. PALMER.
1931–1934. THE APHIDAE OF COLORADO. In: Ann. Ent. Soc. America. PART I, 24 (4) :827–934, figs. 1–100 (1931); PART II, 25 (2) :369–496, figs. 101–208 (1932); PART III, 27 (2) :133–255, figs. 209–333 (1934).

GLOVER, TOWNSEND.
1855. INSECTS INJURIOUS AND BENEFICIAL TO VEGETATION. Rept. Commissioner of Patents for the Year 1854. 59–89.

GREEN, E. E.
1889. DESCRIPTION OF TWO NEW SPECIES OF LECANIUM FROM CEYLON. Entomologist's Monthly Mag. 25:248–250, figs. 1–4.

——— 1896. CATALOGUE OF COCCIDAE COLLECTED IN CEYLON. Indian Mus. Notes 4 (1) :2–10.

——— 1899. THE COCCIDAE OF CEYLON, PART II. 105–168, pls. 31–60. Dulau and Co., London.

——— 1900. SUPPLEMENTARY NOTES ON THE COCCIDAE OF CEYLON. Jour. Bombay Nat. Hist. Soc. 13: 252–257, pls. A–G.

——— 1902. THREE NEW GENERA OF COCCIDAE FROM CEYLON. The Entomologist's Monthly Mag. (II) 13:260–263, figs. 1–3.

——— 1904. THE COCCIDAE OF CEYLON, PART III. 171–249, pls. 61–93. Dulau and Co., London.

——— 1907. NOTES ON THE COCCIDAE COLLECTED BY THE PERCY SLADEN TRUST EXPEDITION TO THE INDIAN OCEAN; SUPPLEMENTED BY A COLLECTION RECEIVED FROM MR. R. DU PONT, DIRECTOR OF AGRICULTURE, SEYCHELLES. Trans. Linn. Soc. London (II) 12:197–207, pl. 21.

——— 1908. REMARKS ON INDIAN SCALE INSECTS. PART III. WITH A CATALOGUE OF ALL SPECIES HITHERTO RECORDED FROM THE INDIAN CONTINENT. Mem. Dept. Agr. India (Ent. Series) 2:15–46, pls. 2–4.

——— 1922. THE COCCIDAE OF CEYLON, PART V. 345–472, pls. 133–191a. Dulau and Co., London.

——— and F. LAING.
1921. COCCIDAE FROM THE SEYCHELLES. Bull. Ent. Research 12:125–128, figs. 1–4.

HADDEN, F. C.
1928. SUGAR CANE MOSAIC AND INSECTS. Hawaiian Planters' Record 32 (1) :130–142.

HAMBLETON, E. J.
1946. STUDIES OF HYPOGEIC MEALYBUGS. Revista de Entomologia 17:1–77, figs. 1–77.

HAUSMANN, FRIEDRICH.
1802. BEITRAGE ZU DEN MATERIALIEN FUR EINE KUNFTIGE BEARBEITUNG DER GATTUNG DER BLATTLAUSE. In: Illiger's Magazin für Insektenkunde 1:426–445.

HOTTES, F. C.
1928. CONCERNING THE STRUCTURE, FUNCTION, AND ORIGIN OF THE CORNICLES OF THE FAMILY APHIDIDAE. Proc. Biological Soc. Washington 41:71–84, pls. 1–10.

——— 1930. THE NAME CINARA VERSUS THE NAME LACHNUS. Proc. Biological Soc. Washington 43:185–188.

——— and T. H. FRISON.
1931. THE PLANT LICE, OR APHIIDAE, OF ILLINOIS. Illinois Nat. Hist. Survey Bull. 19 (3) :121–447, figs. 1–336.

HOWARD, L. O.
1931. THE INSECT MENACE. i–xv, 1–347. Century, New York.

HUGHES-SCHRADER, SALLY.
1930. CONTRIBUTIONS TO THE LIFE HISTORY OF THE ICERYINE COCCIDS, WITH SPECIAL REFERENCE TO PARTHENOGENESIS AND HERMAPHRODITISM. Ann. Ent. Soc. America 23 (2) :359–380.

IMMS, A. D.
1934. A GENERAL TEXTBOOK OF ENTOMOLOGY. i–xii, 1–727, figs. 1–624. E. P. Dutton and Co., New York.

ITO, K.
1932. See CARTER, WALTER, and K. ITO.

——— 1938. STUDIES ON THE LIFE HISTORY OF THE PINEAPPLE MEALYBUG, PSEUDOCOCCUS BREVIPES (CKLL.). Jour. Econ. Ent. 31 (2) :291–298, figs. 1–3.

JENSEN, D. D.
1946. VIRUS DISEASES OF PLANTS AND THEIR INSECT VECTORS WITH SPECIAL REFERENCE TO HAWAII. Proc. Hawaiian Ent. Soc. 12 (3) :535–610.

JONES, M. G.
1942. A DESCRIPTION OF APHIS (DORSALIS) RUMICIS, L. AND COMPARISON WITH APHIS (DORSALIS) FABAE, SCOP. Bull. Ent. Research 33:5–20, figs. 1–7.

KALTENBACH, J. H.
1843. MONOGRAPHIE DER FAMILIE DER PFLANZENLAUSE (PHYTOPHTHIRES). i–xliii, 1–222. Roschütz, Aachen.

KERNER, J. S.
1778. NATURGESCHICHTE DES COCCUS BROMELIAE ODER DES ANANASSCHILDES, NEBST EINEM AUF ERFAHRUNG GEGRUNDETEM VORSCHLAG ZUR GANZLICHEN VERTILGUNG DIESES DEN ANANASPFLANZEN SCHADLICHEN INSECTES. 1–56, pl. 1. Erhard, Stuttgart. [Not seen.]

KERSHAW, J. C.
1913. THE ALIMENTARY CANAL OF FLATA AND OTHER HOMOPTERA. Psyche 20 (6) :175–188, pls. 5–6.

KIRBY, WILLIAM.
1798. HISTORY OF TIPULA TRITICI, AND ICHNEUMON TIPULAE, WITH SOME OBSERVATIONS UPON OTHER INSECTS THAT ATTEND THE WHEAT, IN A LETTER TO THOMAS MARSHAM. Trans. Linnean Soc. London 4:230–239.

KIRKALDY, W. G.
1902. HEMIPTERA. In: Fauna Hawaiiensis, David Sharp, Ed. 3 (2) :93–174, pls. 4, 5. (Cambridge Univ. Press.)

——— 1904. A PRELIMINARY LIST OF THE INSECTS OF ECONOMIC IMPORTANCE RECORDED FROM THE HAWAIIAN ISLANDS. Hawaiian Forester and Agriculturist 1 (6) :152–159; 1 (7) :183–189.

——— 1904. A LIST OF THE COCCIDAE OF THE HAWAIIAN ISLANDS (HEMIPTERA). The Entomologist 37 (495) : 226–230.

——— 1907. A CATALOGUE OF THE HEMIPTEROUS FAMILY ALEYRODIDAE. Board of Commissioners of Agr. and Forestry, Territory of Hawaii, Division Ent. Bull. 2:1–92.

——— 1907. ON SOME PEREGRINE APHIDAE IN OAHU. Proc. Hawaiian Ent. Soc. 1 (3) :99–102.

——— 1908. A BIBLIOGRAPHIC NOTE ON THE HEMIPTEROUS FAMILY ALEYRODIDAE. Proc. Hawaiian Ent. Soc. 1 (5) :185–186.

——— 1908. A LIST OF THE DESCRIBED HEMIPTERA (EXCLUDING ALEYRODIDAE AND COCCIDAE) OF THE HAWAIIAN ISLANDS. Proc. Hawaiian Ent. Soc. 1 (5) :186–208, 3 figs., 1 pl.

——— 1910. NOTES ON THE ANCESTRY OF THE HEMIPTERA. Proc. Hawaiian Ent. Soc. 2 (3) :116–118.

——— 1910. FURTHER NOTES ON HEMIPTERA, CHIEFLY HAWAIIAN. Proc. Hawaiian Ent. Soc. 2 (3) :118–123.

——— 1910. SUPPLEMENT TO HEMIPTERA. In: Fauna Hawaiiensis, David Sharp, Ed. 2 (6) :531–599. (Cambridge Univ. Press.)

KOCH, C. L.
1854–1857. DIE PFLANZENLAUSE, APHIDEN. i–viii, 1–335, pls. 1–54. Lotzbeck, Nürnberg. [Publication dates as follows: Heft 1, figs. 1–45, 1854; Heft 2, figs. 46–94, 1854; Heft 3, figs. 95–134, 1854; Heft 4, figs. 135–181, 1854; Heft 5, figs. 182–227, 1855; Heft 6, figs. 228–268, 1855; Heft 7, figs. 269–310; Heft 8, pp. 237–274, pls. xliii–xlviii, 1856; Heft 9, pp. 275–336, title and pp. vii–viii, pls. xlix–liv, 1857. A complete volume was published in 1857. Dates courtesy E. O. Essig.]

KOEBELE, ALBERT.
1894. REPORT OF ENTOMOLOGIST. In: Biennial Report of Minister of the Interior . . . of the Provisional Government of the Hawaiian Islands. 98–104.

——— 1896. REPORT ON INSECT PESTS. Hawaiian Planters' Monthly 15 (12) :590–598.

——— 1898. REPORT OF THE ENTOMOLOGIST. In: Report of the Minister of the Interior to the President of the Republic of Hawaii for the Biennium Ending 1897. 105–137. (Reprinted in: Hawaiian Planters' Monthly 17:208–219, 1898.)

——— 1901. REPORT OF THE ENTOMOLOGIST. In: Report of the Commissioner of Agriculture and Forestry, Territory of Hawaii, for 1900. 36–49.

——— 1903. REPORT ON LANTANA SCALE. In: Report of the Commissioner of Agriculture and Forestry, Territory of Hawaii, for 1902. 54–65.

KOTINSKY, JACOB.
1907. ALEYRODIDAE OF HAWAII AND FIJI WITH DESCRIPTIONS OF NEW SPECIES. Board of Commissioners of Agriculture and Forestry, Territory of Hawaii, Division Ent. Bull. 2:93–102, pl. 1.

——— 1908. HISTORY AND PRESENT STATUS OF ORTHEZIA INSIGNIS IN HAWAII. Proc. Hawaiian Ent. Soc. 2 (1) :11–12.

——— 1909. TAKAHASHIA JAPONICA (?) CKLL., A COCCID NEW TO HAWAII. Proc. Hawaiian Ent. Soc. 2 (2) :72.

——— 1910. THE SUGAR CANE MEALY BUGS. Proc. Hawaiian Ent. Soc. 2 (3) :110–112.

——— 1910. ASPIDIOTUS CYANOPHYLL [sic] (COCCIDAE) ON SUGAR CANE. Proc. Hawaiian Ent. Soc. 2 (3) : 112.

——— 1910. COCCIDAE NOT HITHERTO RECORDED FROM THESE ISLANDS. Proc. Hawaiian Ent. Soc. 2 (3) : 127–131.

——— 1915. THE BERMUDA GRASS ODONASPIS. Proc. Ent. Soc. Washington 17 (3) :101–104, figs. 1–2.

KUNKEL, L. O.
1922. INSECT TRANSMISSION OF YELLOW STRIPE DISEASE. The Hawaiian Planters' Record 26 (2) : 58–64, 1 fig.

KUWANA, S. I.
1902. COCCIDAE (SCALE INSECTS) OF JAPAN. Proc. California Acad. Sciences (III) 3 (2) :43–98, pls. 7–13.

——— 1909. COCCIDAE OF JAPAN (III). FIRST SUPPLEMENTAL LIST OF JAPANESE COCCIDAE, OR SCALE INSECTS, WITH DESCRIPTION OF EIGHT NEW SPECIES. Jour. New York Ent. Soc. 17 (4) :150–158, pls. 7–9.

——— 1909. COCCIDAE OF JAPAN (IV). A LIST OF COCCIDAE FROM THE BONIN ISLANDS (OGASAWARA–JIMA), JAPAN. Jour. New York Ent. Soc. 17 (4) :158–164, pls. 10–12.

——— 1911. THE WHITE-FLIES OF JAPAN. Pomona Jour. Ent. 3 (4) :620–627, figs. 207–208.

——— 1923. ON THE GENUS LEUCASPIS IN JAPAN. Dobutsugaku-Zasshi 35:319–324, 1 pl.

LAING, F.
1925. DESCRIPTIONS OF SOME NEW GENERA AND SPECIES OF COCCIDAE. Bull. Ent. Research 16:51–66, figs. 1–15.

——— 1932. A NEW APHID-PEST OF VIOLETS. Entomologist's Monthly Mag. (III) 18:52–53.

LINDGREN, D. L., and H. L. MCKENZIE.
1936. ATMOSPHERIC HCN FUMIGATION FOR LATANIA SCALE ON AVOCADO FRUITS. Bull. Dept. Agr. State of California 25 (3) :369–377, fig. 1.

LINDINGER, LEONHARD.
1905. ZWEI NEUE SCHILDLAUSE AUS ASIEN. Insecten-Börse 22:131–133.

——— 1912. DIE SCHILDLAUSE (COCCIDAE) EUROPAS, NORDAFRICAS UND VORDERASIENS . . . 1–388, figs. 1–37. E. Ulmer, Stuttgart.

LINNAEUS, CARL.
1758. SYSTEMA NATURAE. 10th ed. 1–823. L. Salvii, Holmiae.

——— 1761. FAUNA SUECICA. 2nd ed. 1–578, pls. 1–2. L. Salvii, Holmiae.

MACGILLIVRAY, A. D.
1921. THE COCCIDAE (TABLES FOR THE IDENTIFICATION OF THE SUBFAMILIES AND SOME OF THE MORE IMPORTANT GENERA AND SPECIES TOGETHER WITH DISCUSSIONS OF THEIR ANATOMY AND LIFE HISTORY). 1–502. Scarab Press, Illinois.

MCKENZIE, H. L.
1938. THE GENUS AONIDIELLA. Microentomology 3 (1) :1–36, figs. 1–16.

——— 1939. A REVISION OF THE GENUS CHRYSOMPHALUS AND SUPPLEMENTARY NOTES ON THE GENUS AONIDIELLA. Microentomology 4 (2) :51–77, figs. 26–35.

——— 1943. MISCELLANEOUS DIASPID STUDIES INCLUDING NOTES ON CHRYSOMPHALUS. California Dept. Agr. Bull. 32 (2) :148–162, figs. 1–9.

———— 1945. A REVISION OF PARLATORIA AND CLOSELY ALLIED GENERA. Microentomology 10 (2) :47–121, figs. 27–60.

———— 1946. A NEW SPECIES OF LEPIDOSAPHES ATTACKING DENDROBIUM ORCHIDS IN HAWAII AND CALIFORNIA. Proc. Hawaiian Ent. Soc. 12 (3) :611–613, fig. 1. [Correction of original description in: Proc. Hawaiian Ent. Soc. 13 (1) :31, 1947.]

MARTIN, J. P.
1938. SUGAR CANE DISEASES IN HAWAII. 1–295, figs. 1–150, pls. 1–13. Hawaiian Sugar Planters' Association Expt. Station, Honolulu.

MASKELL, W. M.
1879 (1878) . ON SOME COCCIDAE IN NEW ZEALAND. Trans. New Zealand Institute 11:187–228, pls. 5–8.

———— 1885 (1884) . FURTHER NOTES ON COCCIDAE IN NEW ZEALAND. Trans. New Zealand Institute 17: 20–30, pl. 7. [This has been quoted as 1884, but the paper was not read until February 13, 1885, and was printed in May, 1885.]

———— 1887. AN ACCOUNT OF THE SCALE INSECTS OF NEW ZEALAND. New Zealand State Forests and Agr. Dept. 1–116, pls. 1–23.

———— 1889. FURTHER NOTES ON COCCIDAE, WITH DESCRIPTIONS OF NEW SPECIES FROM AUSTRALIA, FIJI, AND NEW ZEALAND. Trans. New Zealand Institute 22:133–156, pls. 4–9.

———— 1890. FURTHER COCCID NOTES: WITH DESCRIPTIONS OF NEW SPECIES FROM NEW ZEALAND, AUSTRALIA, AND FIJI. Trans. New Zealand Institute 23:1–36, pls. 1–7.

———— 1891. FURTHER COCCID NOTES: WITH DESCRIPTIONS OF NEW SPECIES, AND REMARKS ON COCCIDS FROM NEW ZEALAND, AUSTRALIA, AND ELSEWHERE. Trans. New Zealand Institute 24:1–64, pls. 1–13.

———— 1892. FURTHER COCCID NOTES: WITH DESCRIPTIONS OF NEW SPECIES FROM AUSTRALIA, INDIA, SANDWICH ISLANDS, DEMERARA, AND SOUTH PACIFIC. Trans. New Zealand Institute 25:201–252, pls. 11–18.

———— 1895 (1894) . SYNOPTICAL LIST OF COCCIDAE REPORTED FROM AUSTRALASIA AND THE PACIFIC ISLANDS UP TO DECEMBER 1894. Trans. New Zealand Institute 27:1–35.

———— 1895 (1894) . FURTHER COCCID NOTES: WITH DESCRIPTIONS OF NEW SPECIES FROM NEW ZEALAND, AUSTRALIA, SANDWICH ISLANDS, AND ELSEWHERE, AND REMARKS UPON MANY SPECIES ALREADY REPORTED. Trans. New Zealand Institute 27:36–75, pls. 1–7.

———— 1897. ON A COLLECTION OF COCCIDAE, PRINCIPALLY FROM CHINA AND JAPAN. Entomologist's Monthly Mag. (II) 8:239–244.

MASON, P. W.
1925. A REVISION OF THE INSECTS OF THE APHID GENUS AMPHOROPHORA. Proc. U. S. National Mus. 67 (20) :1–92, pls. 1–18.

———— 1937. A NEW ROOT APHID. Proc. Ent. Soc. Washington 39 (6) :166–167, fig. 1.

———— 1940. A REVISION OF THE NORTH AMERICAN APHIDS OF THE GENUS MYZUS. U. S. Dept. Agr. Misc. Pub. 371:1–30, figs. 1–7.

MERRILL, G. B., and JEFF CHAFFIN.
1923. SCALE INSECTS OF FLORIDA. Quarterly Bull. State Plant Board Florida 7 (4) :177–298, figs. 1–116.

MITTLER, SIDNEY.
1946. PRODUCTION OF FEMALE OFFSPRING BY VIRGIN FEMALES IN THE GREENHOUSE WHITE FLY, TRIALEURODES VAPORARIORUM, UNDER THE INFLUENCE OF HIGH TEMPERATURES. American Naturalist 80 (794) :532–546.

MORDVILKO, A.
1928. THE EVOLUTION OF CYCLES AND THE ORIGIN OF HETEROECY (MIGRATIONS) IN PLANT-LICE. Ann. Mag. Nat. Hist. (X) 2 (12) :570–582.

MORGAN, A. C.
1889. OBSERVATIONS ON COCCIDAE (NO. 5) . Entomologist's Monthly Mag. 25:349–353, pl. 5.

MORRILL, A. W.
1905. THE GREENHOUSE WHITE FLY. U. S. Dept. Agr., Bureau Ent., Circular 57:1–9, fig. 1.

MORRISON, HAROLD.
1916. See DIETZ, H. T., and HAROLD MORRISON.

———— 1920. THE NONDIASPINE COCCIDAE OF THE PHILIPPINE ISLANDS, WITH DESCRIPTIONS OF APPARENTLY NEW SPECIES. Philippine Jour. Science 17 (2) :147–202, figs. 1–40, pl. 1.

———— and EMILY MORRISON.
1922. A REDESCRIPTION OF THE TYPE SPECIES OF THE GENERA OF COCCIDAE BASED ON SPECIES ORIGINALLY DESCRIBED BY MASKELL. Proc. U. S. National Mus. 60 (12) :1–120, figs. 1–37, pls. 1–6.

———— 1925. CLASSIFICATION OF SCALE INSECTS OF THE SUBFAMILY ORTHEZIINAE. Jour. Agr. Research 30 (2) : 97–154, figs. 1–42, pls. 1–2.

———— 1925. IDENTITY OF THE MEALYBUG DESCRIBED AS DACTYLOPIUS CALCEOLARIAE MASKELL. Jour. Agr. Research 31 (5) :485–500, figs. 1–5.

———— 1928. A CLASSIFICATION OF THE HIGHER GROUPS AND GENERA OF THE COCCID FAMILY MARGARODIDAE. U. S. Dept. Agr. Tech. Bull. 52:1–240, figs. 1–116, pls. 1–7.

———— 1939. TAXONOMY OF SOME SCALE INSECTS OF THE GENUS PARLATORIA ENCOUNTERED IN PLANT QUARANTINE WORK. U. S. Dept. Agr. Misc. Pub. 344:1–34, pls. 1–11.

MYERS, J. G.
1922. A SYNONYMIC REFERENCE LIST OF THE NEW ZEALAND COCCIDAE. New Zealand Jour. Science and Technology 5:196–201.

NEWMAN, EDWARD.
1869. COCCUS BECKII, A NEW BRITISH HEMIPTERON OF THE FAMILY COCCIDAE. The Entomologist 4: 217–218.

NEWSTEAD, ROBERT.
1901–1902. MONOGRAPH OF THE COCCIDAE OF THE BRITISH ISLES. Ray Society, London. 1:1–220, 34 pls. (1901) ; 2:1–270, pls. 35–37 (1902).

———— and F. C. WILLCOCKS.
1910. CHARACTERS AND GENERAL MORPHOLOGY OF THE LEBBEK SCALE. Bull. Ent. Research 1:138–140, fig. 10.

NIETNER, JOHN.
1861. OBSERVATIONS ON THE ENEMIES OF THE COFFEE-TREE IN CEYLON. 1–31. Ceylon Times. [Not seen.]

OESTLUND, O. W.
1886. LIST OF THE APHIDIDAE OF MINNESOTA, WITH DESCRIPTIONS OF SOME NEW SPECIES. Geological and Nat. Hist. Survey of Minnesota. 17–56.

———— 1918. CONTRIBUTION TO KNOWLEDGE OF THE TRIBES AND HIGHER GROUPS OF THE FAMILY APHIDIDAE. Seventeenth Report, State Entomologist Minnesota. 46–72.

PACKARD, A. S.
1869. GUIDE TO THE STUDY OF INSECTS . . . . i–vi, 1–702 (1868–1869). Naturalist's Book Agency, Salem, Massachusetts.

PALMER, M. A.
1936. ADDITIONS AND CORRECTIONS TO THE "APHIDAE OF COLORADO." Ann. Ent. Soc. America 29 (4) : 729–748, many figs.

PARRIS, G. K.
1938. THE DISEASES OF TRUCK CROPS IN HAWAII. Univ. Hawaii Agr. Extension Bull. 33:1–78, 42 figs.

PATCH, E. M.
1909. HOMOLOGIES OF THE WING VEINS OF THE APHIDIDAE, PSYLLIDAE, ALEURODIDAE AND COCCIDAE. Ann. Ent. Soc. America 2 (2) :101–129, figs. 1–46.

———— 1920. THE LIFE CYCLE OF APHIDS AND COCCIDS. Ann. Ent. Soc. America 13 (2) :156–167.

———— 1938. FOOD-PLANT CATALOGUE OF THE APHIDS OF THE WORLD. Maine Agr. Expt. Station Bull. 393: 1–431.

PERGANDE, THEODORE.
1900. A NEW SPECIES OF PLANT-LOUSE INJURIOUS TO VIOLETS. Canadian Entomologist 32 (2) :29–30.

———— 1904. ON SOME OF THE APHIDES AFFECTING GRAINS AND GRASSES OF THE UNITED STATES. U. S. Dept. Agr., Div. Ent. Bull. 44:5–23, 4 figs.

PERKINS, R. C. L.
1897. THE INTRODUCTION OF BENEFICIAL INSECTS INTO THE HAWAIIAN ISLANDS. Nature 55 (1430): 499–500.

——— 1913. INTRODUCTION. In: Fauna Hawaiiensis. David Sharp, Ed. 1:xv–ccxxviii, pls. 1–16. (Cambridge Univ. Press.)

QUAINTANCE, A. L.
1900. CONTRIBUTIONS TOWARD A MONOGRAPH OF THE AMERICAN ALEURODIDAE. U. S. Dept. Agr., Bureau Ent. (Tech. Ser.) 8:9–64, pls. 1–8.

——— and A. C. BAKER.
1913. CLASSIFICATION OF THE ALEYRODIDAE, PART 1. U. S. Dept. Agr., Bureau Ent. (Tech. Ser.) 27 (1):1–93, pls. 1–34, 11 text figs.

——— ——— 1914. CLASSIFICATION OF THE ALEYRODIDAE, PART 2. U. S. Dept. Agr., Bureau Ent. (Tech. Ser.) 11:95–109, pls. 35–48.

——— ——— 1915. CLASSIFICATION OF THE ALEYRODIDAE. [Contents, index and corrigenda.] U. S. Dept. Agr., Bureau Ent. (Tech. Ser.) 27:i–xi, 111–114.

——— ——— 1917. A CONTRIBUTION TO OUR KNOWLEDGE OF THE WHITE FLIES OF THE SUBFAMILY ALEYRODINAE. Proc. U. S. National Mus. 51:335–445, pls. 32–77.

RUSSELL, L. M.
1941. A CLASSIFICATION OF THE SCALE INSECT GENUS ASTEROLECANIUM. U. S. Dept. Agr. Misc. Pub. 424:1–322, pls. 1–9, figs. 1–84.

——— 1946. THE IDENTITY OF CHERMES ALNI LINNE, 1758. Proc. Ent. Soc. Washington 48 (9):249–250.

——— 1948. THE NORTH AMERICAN SPECIES OF WHITE-FLIES OF THE GENUS TRIALEURODES. U. S. Dept. Agr. Misc. Pub. 635:1–85, figs. 1–34.

RUTHERFORD, A.
1915. SOME CEYLON COCCIDAE. Bull. Ent. Research 5:259–268.

SAMOUELLE, GEORGE.
1819. THE ENTOMOLOGIST'S USEFUL COMPENDIUM, OR AN INTRODUCTION TO THE KNOWLEDGE OF BRITISH INSECTS. . . . 1–496, 12 colored pls. Boys, London.

SAMPSON, W. W.
1943. A GENERIC SYNOPSIS OF THE HEMIPTEROUS SUPERFAMILY ALEYRODIDAE. Entomologica Americana 23 (3):173–223.

——— 1946. GENERIC CLASSIFICATION OF CALIFORNIA APHIDS BY MEANS OF FIRST INSTAR NYMPHS. Univ. California Pubs. Ent. 7 (12):365–402, 57 figs.

SANDERS, J. G.
1906. CATALOGUE OF RECENTLY DESCRIBED COCCIDAE. U. S. Dept. Agr., Bureau Ent. (Tech. Ser.) 12 (1):1–18.

——— 1909. CATALOGUE OF RECENTLY DESCRIBED COCCIDAE, PART II. U. S. Dept. Agr., Bureau Ent. (Tech. Ser.) 16 (3):33–60.

——— 1909. THE IDENTITY AND SYNONYMY OF SOME OF OUR SOFT SCALE-INSECTS. Jour. Econ. Ent. 2 (6): 428–448, pls. 19–20.

SASSCER, E. R.
1911. CATALOGUE OF RECENTLY DESCRIBED COCCIDAE—III. U. S. Dept. Agr., Bureau Ent. (Tech. Ser.) 16 (4):61–74.

——— 1912. CATALOGUE OF RECENTLY DESCRIBED COCCIDAE—IV. U. S. Dept. Agr., Bureau Ent. (Tech. Ser.) 16 (6):83–97.

——— 1913. AN INDEX TO CATALOGUES OF RECENTLY DESCRIBED COCCIDAE INCLUDED IN TECHNICAL SERIES NOS. 12 AND 16. U. S. Dept. Agr., Bureau Ent. (Tech. Ser.) 16 (7):99–116.

——— 1915. CATALOGUE OF RECENTLY DESCRIBED COCCIDAE—V. Proc. Ent. Soc. Washington 17:25–38.

SCHMIDT, C. T.
1944. THE IMMUNITY OF PSEUDOCOCCUS BREVIPES (CKLL.) TO PARASITISM BY COCCOPHAGUS GURNEYI COMPERE. Proc. Hawaiian Ent. Soc. 8 (3):517–518.

SCHRADER, FRANZ.
1926. NOTES ON THE ENGLISH AND AMERICAN RACES OF THE GREENHOUSE WHITE-FLY (TRIALEURODES VAPORARIORUM). Ann. Applied Biology 13:189–196.

SCUDDER, S. H.
1893. THE AMERICAN APHIDIDAE WITH A LIST OF THE KNOWN SPECIES AND TABLES FOR THEIR DETERMINATION. U. S. Geological Survey, 13th Annual Rept. (1891–1892). 341–372, pls. 102–106.

SHINJI, G. O.
1917. MATING HABIT OF THE COTTONY CUSHION SCALE. Entomological News 28 (4):162–165.

SIGNORET, V.
1861. In: P. Montrouzier's Essai sur la Fauna Entomologique de la Nouvelle-Calédonie. Ann. Soc. Ent. France (IV) 1:59–74.

———— 1863. HEMIPTERES. In: Abbé Maillard's Notes sur l'Ile de la Réunion, 2nd ed., 2 (annex J): J-26–J-31. Paris.

———— 1869. ESSAI SUR LES COCHENILLES OU GALLINSECTES, PART 4. Ann. Soc. Ent. France (IV) 9:109–138, illustrated.

———— 1869. ESSAI SUR LES COCHENILLES OU GALLINSECTES, PART 5. Ann. Soc. Ent. France (IV) 9:431–452, 3 pls.

———— 1873. ESSAI SUR LES COCHENILLES OU GALLINSECTES. Ann. Soc. Ent. France (V) 3:395–448, pls. 12–13.

———— 1882. OBSERVATIONS SUR HEMIPTERES. Bull. Soc. Ent. France xxxv–xxxvi.

SILBERMANN, GUSTAVE.
1837. In: Revue Entomologique 5:1–351. Paris.

SNODGRASS, R. E.
1935. PRINCIPLES OF INSECT MORPHOLOGY. 1–667, figs. 1–319. McGraw-Hill, New York.

SOLIMAN, L. B.
1927. A COMPARATIVE STUDY OF THE STRUCTURAL CHARACTERS USED IN THE CLASSIFICATION OF THE GENUS MACROSIPHUM OF THE FAMILY APHIDIDAE, WITH SPECIAL REFERENCE TO THE SPECIES FOUND IN CALIFORNIA. Univ. California Pubs. Ent. 4 (6):89–158, figs. 1–77.

STEINWEDEN, J. B.
1929. BASES FOR THE GENERIC CLASSIFICATION OF THE COCCOID FAMILY COCCIDAE. Ann. Ent. Soc. America 22 (2):197–243, figs. 1–6, pls. 1–2.

———— 1930. CHARACTERISTICS OF SOME OF OUR CALIFORNIA SOFT SCALE INSECTS. Monthly Bull. California State Dept. Agr. 19 (8):561–571, pls. 1–3.

STICKNEY, F. S.
1934. THE EXTERNAL ANATOMY OF THE RED DATE SCALE, PHOENICOCCUS MARLATTI COCKERELL, AND ITS ALLIES. U. S. Dept. Agr., Tech. Bull. 404:1–163.

SUEHIRO, AMY.
1937. NEW RECORDS OF MEALYBUGS IN HAWAII. Proc. Hawaiian Ent. Soc. 9 (3):429–430.

SWAIN, A. F.
1919. A SYNOPSIS OF THE APHIDIDAE OF CALIFORNIA. Univ. California Tech. Bull. Ent. 3 (1):1–221, pls. 1–17.

SWEETMAN, H. L.
1936. THE BIOLOGICAL CONTROL OF INSECTS. 1–461, figs. 1–142. Comstock Publishing Co., Ithaca, New York.

SWEZEY, O. H.
1913. SUGAR CANE MEALY BUGS IN THE HAWAIIAN ISLANDS. Hawaiian Planters' Record 8 (4):200–208, figs. 1–6.

TAKAHASHI, RYOICHI.
1921. APHIDIDAE OF FORMOSA, PART 1. Taihoku Agr. Expt. Station Government of Formosa, Special Bull. 20:1–97, pls. 1–15.

———— 1923. APHIDIDAE OF FORMOSA, PART 2. Dept. Agr. Government Research Institute, Formosa, report 4, 1–173, pls. 1–9.

———— 1924. APHIDIDAE OF FORMOSA, PART 3. Dept. Agr. Government Research Institute, Formosa, report 10, 1–121, pls. 1–10.

———— 1925. APHIDIDAE OF FORMOSA, PART 4. Dept. Agr. Government Research Institute, Formosa, report 16, 1–65, pls. 1–4.

———— 1927. APHIDIDAE OF FORMOSA, PART 5. Dept. Agr. Government Research Institute, Formosa, report 22, 1–22, pls. 1–2.

———— 1927. SOME APHIDIDAE COLLECTED BY DR. F. SILVESTRI IN CHINA. Bolletino del Laboratorio di Zoologia Generale e Agraria, Portici 20:147–149.

———— 1929. APHIDIDAE AND COCCIDAE OF THE PESCADORES. Trans. Nat. Hist. Soc. Formosa 19 (104): 425–431.

———— 1931. APHIDIDAE OF FORMOSA, PART 6. Dept. Agr. Government Research Institute, Formosa, report 53, 1–127.

———— 1934 (1935). A NEW SPECIES OF APHID FROM THE MARQUESAS. In: Marquesan Insects—II. Bernice P. Bishop Mus. Bull. 114:287–288, fig. 1.

———— 1937. A NEW APHID FROM MAURITIUS. Proc. Royal Ent. Soc. London (B) 6:105–106, fig. 1.

TARGIONI-TOZZETTI, ADOLFO.
1867. STUDII SULLE COCCINGIGLIE. Mem. Soc. Italiana Sci. Nat. 3 (3): 1–81, pls. 1–7.

THEOBALD, F. V.
1915. AFRICAN APHIDIDAE.—PART II. Bull. Ent. Research 6:103–153, figs. 1–38.

———— 1920. AFRICAN APHIDIDAE.—PART IV. Bull. Ent. Research 11:65–72, figs. 1–6.

———— 1926. THE PLANT LICE OR APHIDIDAE OF GREAT BRITAIN. 1:1–372, 196 figs. Headley Brothers, London.

———— 1927. THE PLANT LICE OR APHIDIDAE OF GREAT BRITAIN. 2:1–411, 182 figs. Headley Brothers, London.

———— 1929. THE PLANT LICE OR APHIDIDAE OF GREAT BRITAIN. 3:1–364, 213 figs. Headley Brothers, London.

THOMAS, CYRUS.
1879. EIGHTH REPORT OF THE STATE ENTOMOLOGIST OF THE NOXIOUS AND BENEFICIAL INSECTS OF THE STATE OF ILLINOIS. 1–212.

THRO, W. C.
1903. DISTINCTIVE CHARACTERISTICS OF THE SPECIES OF THE GENUS LECANIUM. Cornell Univ. Agr. Expt. Station Bull. 209:205–221, pls. 1–5.

TIMBERLAKE, P. H.
1924. NOTES ON HAWAIIAN APHIDAE, WITH A LIST OF FOOD PLANTS. Proc. Hawaiian Ent. Soc. 5 (3): 450–460.

———— 1927. BIOLOGICAL CONTROL OF INSECT PESTS IN THE HAWAIIAN ISLANDS. Proc. Hawaiian Ent. Soc. 6 (3): 529–556, 5 figs., pls. 19–23.

TINSLEY, J. D.
1900. CONTRIBUTIONS TO COCCIDOLOGY.—II. Canadian Entomologist 32 (3): 64–67.

TOWNSEND, C. H., and T. D. A. COCKERELL.
1898. COCCIDAE COLLECTED IN MEXICO BY MESSRS. TOWNSEND AND KOEBELE IN 1897. Jour. New York Ent. Soc. 6 (3): 165–180.

TUTHILL, L. D.
1943. THE PSYLLIDS OF AMERICA NORTH OF MEXICO. Iowa State College Jour. Science 17 (4): 443–660, 313 figs.

UICHANCO, L. B.
1924. STUDIES OF EMBRYONGENY AND POSTNATAL DEVELOPMENT OF THE APHIDIDAE WITH SPECIAL REFERENCE TO THE HISTORY OF THE "SYMBIOTIC ORGAN," OR "MYCETOM." Philippine Jour. Science 24 (2): 143–247, pls. 1–13.

VALLOT, J. N.
1829. NOUVELLES ESPECES DE COCHENILLES. Acad. Science, Arts et Belles-Lettres, Dijon. 30–33. [Not seen.]

VAN DER GOOT, P.

1917. ZUR KENNTNISS DER BLATTLAUSE JAVAS. In: Contribution des Faune Indes Neerland. 1 (3): 1–301, many figs. Buitenzorg.

———— 1918. NOTES ON ORIENTAL APHIDIDAE. Tijdschrift Entomologie 60:112–127, figs. 1–5.

VAN DINE, D. L.

1904. THE PINEAPPLE SCALE. Hawaiian Forester and Agriculturist 1 (5) :111–114, pl. 1.

———— 1906. THE AVOCADO MEALY-BUG. Hawaii Agr. Expt. Station Press Bull. 16:1–12, figs. 1–3.

WHITE, W. S.

1946. THE ENVIRONMENTAL CONDITIONS AFFECTING THE GENETIC MECHANISM OF WING PRODUCTION IN THE CHRYSANTHEMUM APHID. American Naturalist 80 (790) :245–270.

WILLCOCKS, F. C.

1910. A MEALY BUG INJURIOUS TO THE LEBBEK TREES OF CAIRO. Bull. Ent. Research 1:121–137, figs. 1–9, pl. 10.

WILLIAMS, F. X.

1931. THE INSECTS AND OTHER INVERTEBRATES OF HAWAIIAN SUGAR CANE FIELDS. 1–400, figs. 1–190. Hawaiian Sugar Planters' Association Expt. Station, Honolulu.

WILSON, H. F.

1908. THE GREEN APHIS OF CHRYSANTHEMUM—APHIS RUFOMACULATUS, N.SP. Entomological News 19 (6) :261–262.

———— 1910. A KEY TO THE GENERA OF THE SUBFAMILY APHIDINAE AND NOTES ON SYNONYMY. Ann. Ent. Soc. America 3 (4) :314–325.

———— and R. A. VICKERY.

1918. A SPECIES LIST OF THE APHIDIDAE OF THE WORLD AND THEIR RECORDED FOOD PLANTS. Trans. Wisconsin Acad. Sciences, Arts and Letters 29 (1) :22–255.

ZEHNTNER, L.

1897. OVERZICHT VAN DE ZIEKTEN VAN HET SUIKERRIET OP JAVA [PART 2]. Archief voor de Java-Suikerindustrie 5 (1) :525–575.

ZIMMERMAN, E. C.

1946. BROWNE 1887, NOT DOUGLAS 1888, THE AUTHOR OF ORTHEZIA INSIGNIS. Proc. Hawaiian Ent. Soc. 12 (3) :657–658.

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